A STORY OF RAILWAY PIONEERS

Major S. SNELL, M.C. (Ex R.E.)

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ISAAC DODDS

To whose genius is due much of the scientific advancement of railways.

A STORY OF RAILWAY PIONEERS

BEING AN ACCOUNT OF THE INVENTIONS AND WORKS OF

ISAAC DODDS

AND HIS SON

THOMAS WEATHERBURN DODDS

BY

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PREFACE

The historical records of the Science of Engineering are notoriously incomplete and general knowledge of the origin of commonplace inventions is lamentably poor.

The nineteenth century produced many remarkable men whose works are everywhere in constant use, but whose names are lost to History.

This story, originally intended for publication in a well-known magazine, is offered to the reader who can appreciate a record of the inventions and works of noble minds and who takes a just pride in the achievements of his countrymen.

Upon the death of Mr. Isaac Dodds, in 1882, *practically no public mention was made of his contributions to engineering science; only the late Mr. Charles Manby, Secretary of the Institute of Civil Engineers, ventured to record some of his works. Following Mr. Dodds' decease, his son, Mr. T. W. Dodds, was occupied for considerable time in work abroad, and returned to England with*

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his health failing. His death took place shortly afterwards, in the last year of the nineteenth century.

Eleven years afterwards the writer had the good fortune to see evidence of the Messrs. Dodds' remarkable inventions, and commenced a careful investigation of their life works as far as family papers would permit. Many of the original notes, drawings, and other documents were destroyed subsequent to the death of Mr. T. W. Dodds; sufficient evidence remained, however, to show that a permanent record of their doings would be of interest to many readers even at the present time.

The newspaper notices published after the death of Mr. T. W. Dodds, although doing little enough justice to his memory, provided clues sufficient to guide the investigator into those channels where more information might be learned.

Former workmen of the firm of Dodds and Son were sought out and interviewed, their stories being heard with great interest; relics of their apprentice days treasured up for sixty years or more were brought to light on these occasions and exhibited with remarkable pride, then replaced in a way which was pathetic to the beholder.

These men were all proud of their masters, and respected them with complete sincerity, bearing their memory to the grave.

PREFACE

Many old records have been searched, old newspapers, column by column, the few contemporary engineering publications, and many scientific journals. Visits have been paid to the scenes of their activities, and local records examined. Many inventions have of necessity been omitted as complete evidence concerning them was lacking; even in some of these cases, however, there is little doubt that a jury would give the credit of their origin to the Messrs. Dodds, but in a record of this nature, where frequent footnotes and references have been avoided, it is probably the wisest plan to omit them.

Should the facts and incidents related in this story be of value, in that it may furnish some of the missing links in the history of engineering, then, apart from any interest which it might create, the writer thinks his time and trouble well repaid.

S. S.

Toronto, Canada,
1921.

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INTRODUCTION

In the world's history of travel, the most important event affecting civilization is unquestionably the adoption of mechanical transport on a carefully planned system of railways. With the inception of this new means of communication in the course of a remarkably short period, our social and industrial life completely changed. To this invention Britain owes her proud position as a great nation, and her peoples should never forget those few of her countrymen who, with almost supernatural strength and foresight, fought down the prejudice of the leading political and scientific figures of the day, and enabled their inventions to mature into practical and accomplished works.

In the stress of twentieth-century life we are apt to forget that we owe a vast debt to the men who invented and introduced that great civilizing element, the steam locomotive railway. A newly discovered country can only be effectively deve-

loped by means of the railway; for distance has found its master: a thousand miles to the modern steam-horse is as a hundred to the coach-horse of olden times.

The modern mind remains unaffected by the wonders surrounding it, just as 'the peasant will dwell beneath the mountain range, whose colossal peaks are covered with eternal snows, without feeling any homage for its grandeur'; or as 'multitudes will wander heedlessly upon the shore, unconscious of the sublimity of the ocean.' Such is the case to a great extent with those who receive all the benefits conferred by our railways, for it is surprising how little is generally known of those who made it their life's work to give this country a means of improvement for its wealth and convenience. Samuel Smiles has bequeathed to us biographies of a few of these great men, but it is to be regretted that his records were not more complete; for to-day we have comparatively little information about those who worked in the background, and whose inventive genius provided others with fortune and everlasting fame.

At the beginning of the railway period, from 1821 to 1840, the inventors and promoters alike were regarded as dangerous lunatics, and the bare mention of the word 'speed' was sufficient to

cause them trouble with various authorities whose favour they sought to obtain.

Evidence taken as late as 1834 before the House of Lords Committees for the hearing of the Sheffield and Rotherham Railway Bill showed that even then the stupid prejudice had by no means died out; the following is typical of an Engineer's cross-examination:—

(George Stephenson is called in and cross-examined by Mr. Pollock, K.C.).

You are a civil engineer?—Yes. Have you been conversant with railways?—Yes. Without asking, will you enumerate some of them?—The Liverpool and Manchester Railroad, the Stockton and Darlington and a great number in the North of England before I commenced the Stockton and Darlington Line; I don't recollect them all. I believe you are called by some persons the 'Father of Railways'?—I do not know. Perhaps I have been the means of bringing them forward. Have you considered the Line of the Sheffield and Rotherham as laid down by Mr. Swanwick?—I have. Are you sufficiently acquainted with the locality to be able to form a tolerable judgment upon the subject?—I am. Do you concur with him in the estimates that he has made, and in the eligibility of the line which he has selected?—

I do, quite so. Can you state, from your knowledge of the neighbourhood, whether so good a line, with reference to expense, could have been laid down elsewhere as that which Mr. Swanwick has laid down?—There could not, I am confident of. We understand that Mr. Swanwick was bred under your tuition as an engineer?—Yes, he received instruction under me. Do you think he possesses judgment, discretion, and experience enough to be entrusted with the execution of this railway, as well as the details?—I do; he has always been very accurate in his estimates, and always very correct in his judgment. I should trust him as soon as any young man I know. . . .

The few popular journals of this period were also strongly against the general adoption of railways, a typical publication called the 'Popular Encyclopædia,' dated 1832, was responsible for the following opinion:—

'The unprecedented mania for railways over the country to supersede the present excellent system of inland navigation, which has done so much for our commerce, is likely to terminate as all such dreams have hitherto done, viz. in the disappointment and loss of many for the enrichment of the few.' This statement was ventured by the learned Dr. Olinthius Gregory, who was at that time a most important figure in the

scientific world. It is to be hoped that at the 'Trump of Doom's Tone' gentlemen of this kind will have the privilege of looking at the world's developments, since their day, in order that they might see the glory and triumph of an invention they themselves tried so hard to belittle.

Those who take an interest in the history of railways know that credit for their introduction has never been given as it ought. Our poets and writers have given little thought to praising the wonderful works of mankind, their plaudits have mostly been bestowed on the works of Nature, adventurers in love and war, etc. If therefore there are any readers of this book who have poetical aspirations the stories of the doings of the early railway pioneers would prove an excellent theme. Ebenezer Elliot seems to have attempted to express in poetry his opinions on railways, probably it was because he lived in a manufacturing district; in his 'Stanzas on the opening of the Sheffield and Rotherham Railway,' the 'Corn-Law Rhymer' speaks as follows:—

They come! the shrieking steam ascends,
  Slow moves the banner'd train;
They rush! the tow'ring vapour bends;
  The kindled wave again
Screams over thousands, thronging all
  To witness now the funeral
  Of law-created pain.

Fire-kindling man! thy life-stream runs,
  Ev'n yet through sighs and groans;
Too long thy Watts and Stephensons
  With brains have fattened drones.
O Genius! all too long, too oft
At thee the souls of clay have scoffed
  And sold thy little ones!

Although the steam locomotive was, when introduced, the means of industrially placing us ahead of all other nations, we find that our standard histories refer quite casually to the event; far more attention is given to the wives of Henry the Eighth, or to some political riot of common-place importance.

In the following chapters there are recorded the works and inventions of an old railway pioneer and his son, who, though not known to the public so well as the Stephensons and others, yet contributed in a remarkable degree many of those detailed appliances which made railways an extraordinary success.

CHAPTER I

ISAAC DODDS

ISAAC DODDS was born on the 9th of July, 1801, at Felling Hall in the county of Durham; his father, Thomas Dodds, a gentleman of considerable means, was manager of the Felling Colliery, Hewarth. When Isaac was only four years of age a great misfortune befell the family, for on the 21st of October, 1805, Thomas Dodds, with thirty-four others, was killed in the terrible explosion which took place at Hebburn Colliery, near Newcastle. Mining at that time was carried on in a most hazardous way, little or nothing being known of the various geological phenomena; and coal was drawn from the pit bottom by means of a hand windlass or by horse-power. There was little wonder, then, that accidents, involving heavy loss of lives, were frequent, and as the result of an explosion of gas in the mine workings Thomas Dodds received fatal injuries.

This misfortune to the Dodds family was shortly to be followed by another, for, although left

in comfortable circumstances, their trustee defrauded them out of practically all their dead father's estate. For several years they struggled to make a living, the children being sent out into the world at a very early age to earn money for their own support. When, therefore, Isaac Dodds was only ten years old he was compelled to work for the livelihood of his widowed mother and his brothers and sisters. His schooling was not, however, neglected, for in the evenings he took lessons from Willie Woolhave, the local Parish Clerk, who was a man possessed of great natural talents, and, although holding a humble position in life, was responsible for some valuable inventions. Many years afterwards, on the death of his old tutor, Isaac Dodds wrote: 'To Willie Woolhave we are indebted for the lifeboat, though it was first patented by a Mr. Greathead; he was also the inventor of the first safety lamp I ever saw. This was like a large parrot cage enclosing a glass lamp, the air being supplied from bellows worked by the collier's knees, using the air from the lowest strata. Dr. Clanny brought out a lamp about the same time, but I believe the idea was derived from Mr. Woolhave; on his death the inhabitants of South Shields raised a subscription for a tombstone on which was carved the lifeboat.'

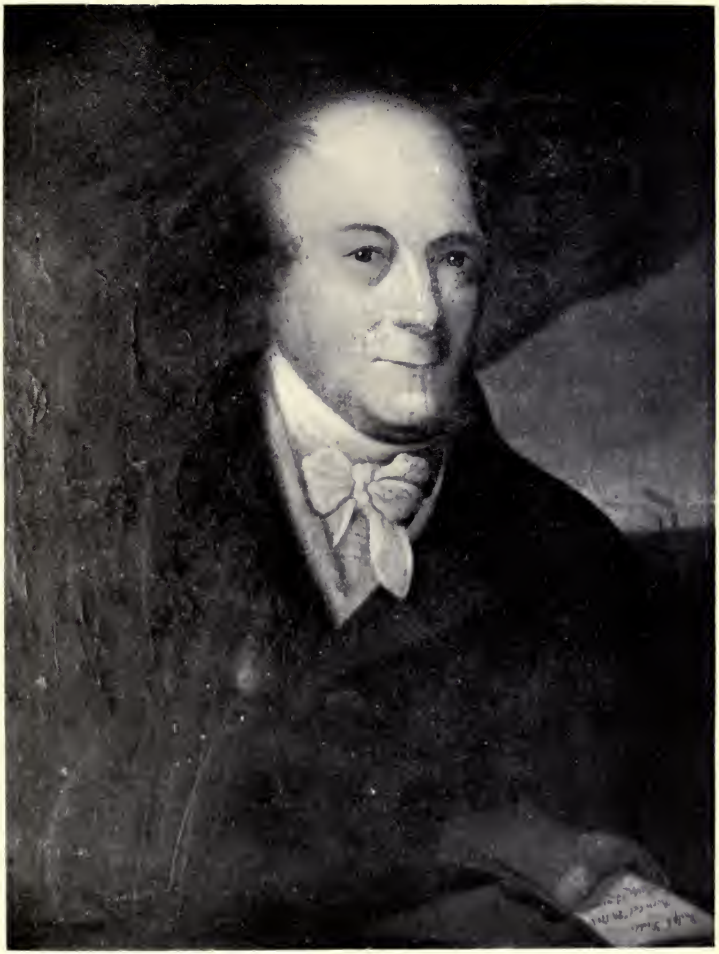
Isaac proved himself to be an industrious pupil, and soon astonished his teacher with his extraordinary aptitude for mathematics and his genius for making beautiful drawings. His education under Woolhave lasted until the latter part of 1812, when he was to receive valuable help in his training from another source. His uncle, Ralph Dodds, of Killingworth Colliery, wrote to Isaac's mother offering to take her son as a mining engineer pupil at that Colliery. Mrs. Dodds decided to accept this offer, and made all the necessary arrangements to send her boy to his new situation.

It was, therefore, with many true regrets that Isaac said farewell to his old home and associates, and particularly to his old counsellor and friend Willie Woolhave, who had done everything in his power to encourage the boy's desire for knowledge and at the same time to inspire him with great ideals.

When nearly twelve years of age young Isaac Dodds found himself safely installed in his Uncle's office at Killingworth Colliery working hard to become a mining engineer. Ralph Dodds was greatly pleased with his pupil and gave him many opportunities for seeing and learning as much as possible about the operations of coal-mining.

It was only a short time after Isaac Dodds had

commenced his new duties when a very remarkable event took place, which was the means of bringing forward in our country one of its noblest and most important characters; all those of our readers who are acquainted with Samuel Smiles's 'Life of George Stephenson' will recall the incident. It appeared that early in the year 1815 at the Killingworth Colliery, owned by Lord Ravensworth, a new pumping engine had been installed; it was of the Newcomen atmospheric type, and at that time was considered to be a very modern and efficient machine, notwithstanding its colossal capacity for consuming coal. For several weeks the engine kept the pumps at work, but one morning it suddenly stopped without apparent cause or reason. The enginewrights were soon busy at work trying to locate the source of the trouble. Their efforts were, however, in vain, and as the pumps were not operating the water in the mine quickly rose to such a height that continuation of work became impossible. The situation was getting worse as days passed by, Ralph Dodds the manager being in great despair, for the experts, who by this time had arrived from the maker's works, advised that the engine should be completely dismantled and sent back to their factory for further examination. This the manager was loth to do, as it would mean



Reproduced from an oil-painting by] [*kind permission of Miss C. E. Dodds*

RALPH DODDS

Chief Viewer to the Grand Allies Collieries at Killingworth, who gave George Stephenson his 'start' in life. Nicholas Wood, who wrote the 'Treatise on Railroads,' and Blenkinsop—inventor of the 'rack' railway—were also trained by him.

ceasing work at the mine for many weeks. One morning, however, when Ralph Dodds had reached his office at the Colliery, he was informed by the chief clerk that his foreman sinker, Christopher Heppel by name, was waiting to see him. He, therefore, ordered Heppel into his office and inquired the reasons for this interview. Heppel thereupon said, 'You have a man here, named George Stephenson, who says that he can repair the engine and drain the pit within a week'; the astonished manager replied, 'Send him to me; if he does I will make a man of him.' It is a matter of common knowledge with every schoolboy how that Stephenson repaired the engine and had the pumps in action in a very short space of time, also that the Newcomen engine worked as it had never done before. Ralph Dodds was naturally delighted with the results of Stephenson's work and appointed him assistant enginewright at the colliery, giving him also a holiday and a present of ten pounds.

Some few months after this event Ralph Dodds and George Stephenson* became joint-patentees

*An interesting reminiscence was recently related to the writer by a descendant of Mr. John Stephenson. This gentleman spent many holidays with his grandmother, Mrs. J. Stephenson (who was a sister of Isaac Dodds), during his boyhood and well remembers that lady telling him of the following among her many interesting reminiscences:—

As a girl Miss Dodds often stayed with her Uncle Ralph Dodds of the Killingworth Collieries, and would often accom-

in a steam locomotive, the date of the patent being the 28th of February, 1815. The engine was built at Killingworth and employed there in shunting wagons about the yards; it was far in advance of any engine built up to that date, and soon made for itself a wide reputation in engineering circles.

In his reminiscences of these early days Isaac Dodds once said, with regard to this machine: 'The engine was made, and I now venture my humble opinion that for the purpose for which it was required—viz., a colliery locomotive, to draw coals on a railway—it was at the time the very best that had been brought out; it worked most successfully, and all who saw its performance were satisfied that a great step had been made towards a complete locomotive, requiring only time, experience, and perseverance to give it all that the votaries of a "travelling steam horse"

pany the carriage which used to take him to his office and back to his residence; she was invariably attended by a maid, and on arriving at the Colliery offices, she was told to wipe her feet before walking on the carpet at the entrance, although she had only stepped into the carriage and out again, and notwithstanding the fact that she had frequently seen a man with mud-caked boots and dirty clothes go in without doing so!

This man was George Stephenson (no relation to John Stephenson) and Miss Dodds often saw him in the offices at Killingworth looking over her Uncle's shoulder at drawings and discussing various matters with him.

The first 'Killingworth' locomotive was built to the order of Ralph Dodds, and to him is largely due the credit for its construction.

desired; it showed that a "steam horse" was not only possible, but that it contained a germ of speed and power to overcome all animal power.'

Young Isaac Dodds was a privileged listener and spectator at these discussions and trials of the locomotive; it is said that he displayed remarkable intelligence and understanding of the subject. For some months he busied himself in his leisure hours by making a model of the engine previously patented by his Uncle Ralph and Stephenson, but had considerable difficulty in making the arrangement for coupling the driving wheel to the other carrying wheels; he therefore decided to eliminate the cogged wheels of the big engine and use a simpler appliance on his model. He obtained two spinning wheels for this experiment and coupled them together by means of strong rods attached to bolts, which were fastened to the wheels in precisely the same position, so that the power applied to one wheel would be constantly transmitted to the other. Having made the model and got it to work satisfactorily, Isaac showed it to his Uncle Ralph and to George Stephenson; they saw at once the advantage of this method over their own, and they decided to discard their system of coupling, as used on the Killingworth locomotive, and try the coupling rods. The alteration was soon carried out and

gave great satisfaction to the designers, for this part of the engine had previously given continuous trouble, as the cog wheels used to transmit the power would not stand the varying shocks received when the engine was travelling at five or six miles an hour.

Writing in reference to the origin and responsibility for the invention of coupling rods in place of other modes of transmitting power, Nicholas Wood, the author of one of the earliest works on Railroads and who succeeded Ralph Dodds as manager of Killingworth Colliery, says: 'It was subsequently suggested by the late ingenious Mr. Ralph Dodds that the motion of the pistons might be transferred directly to the wheels without the aid of the intermediate cog wheels. He proposed that each connecting rod should be attached by a ball-and-socket joint to a pin on a spoke of one of the wheels; and he assumed that by this means the reciprocating motion of the piston and connecting rod would be converted by the pin upon the spokes, acting as a crank, into a rotary motion.' And that all that was necessary to secure continuation of this rotary motion would be to keep the one pin or crank at right angles to the other. An engine so constructed was tried on the Killingworth Railroad on March 6, 1815, and was found to work remarkably well.'

The year 1815 proved to be very eventful for Isaac Dodds, as the incidents in which he took part had very far-reaching results of inestimable value to the engineering world. In November of the same year he had the privilege of accompanying a party of eighteen distinguished mining and civil engineers down the Grand Allies Pit at Killingworth to test the first miner's safety lamp. Nicholas Wood, the well-known authority on railroads, was one of the party, and took great pains to explain to Isaac the principles of the lamp, also the reasons why they expected to be successful in their design, and thus solve a problem which would mean the saving of many lives, at the same time enabling the coal-mining industry to be developed in spite of dangers caused by the mine gases of an inflammable nature. The experiment was a distinct success, and, although a lamp of similar pattern was brought out almost at the same time by Humphry Davy, this lamp was the standard type used in many mines of the North-East Coalfields for years afterwards.

Ralph Dodds was delighted with his nephew's progress, for Isaac had quickly revealed a natural ability for work of a mechanical nature, and showed far more interest in the enginewright's shop than he did in the problems of coal-mining; his observant uncle, quite aware of this, decided

to let him work with George Stephenson, who by this time had become chief enginewright. The change of occupation was a source of satisfaction to both Isaac and his new chief, and from that time he and George Stephenson were inseparable companions; if anything went wrong with the machinery in the pit Isaac would accompany George Stephenson down the mine with his sketch-book in hand to make a drawing of the broken part; the mine shafts were in those days descended by means of a cross-bar attached to the windlass rope, and Isaac would take up his position on Stephenson's knee, who was seated on the crosspiece, and in this way be lowered to the pit bottom.

CHAPTER II

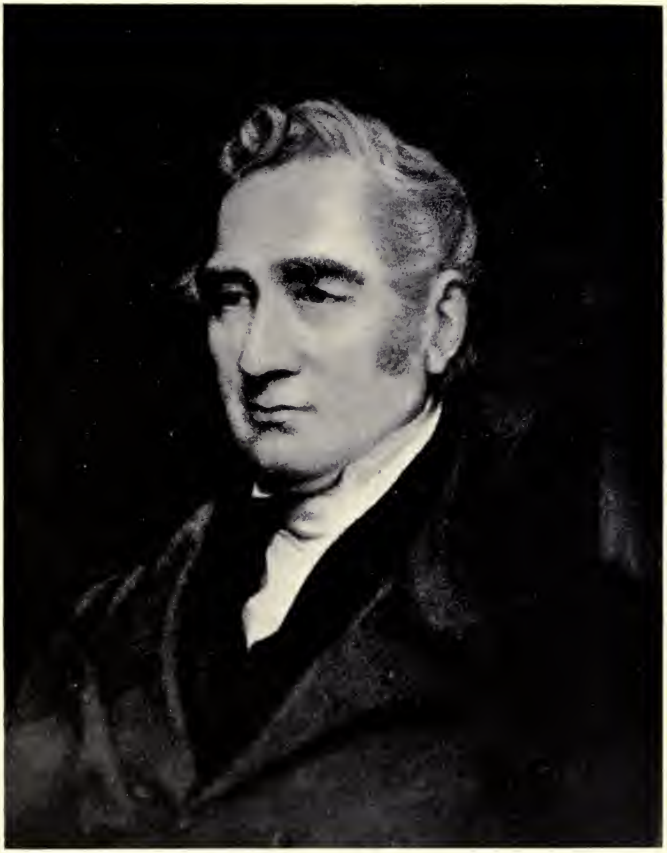
GEORGE STEPHENSON AND JAMES HANN

In 1823, with the assistance of several well-known business men, George Stephenson removed from Killingworth to Newcastle-on-Tyne, and proceeded to open the engineering works at Forth Street which now bear his son Robert's name; it was also arranged that Isaac Dodds should accompany him and there complete his pupilage. Here again Isaac proved himself to be a workman of exceptional skill and capacity, and during his leisure made a model locomotive after his own design and introduced horizontal cylinders in place of the vertical cylinders then in general use. His model was tested under steam and gave its young creator such proof and confidence by its smooth running and general behaviour that he told the results of his experiments to Stephenson, strongly advocating the principle of horizontal cylinders. Stephenson, however, gnored his contention, saying he thought the cylinders would wear out owing to the heavy strain on the bottom.

In the latter part of his employment and training under Stephenson at the Forth Street Works, Isaac Dodds acted as chief technical adviser and calculator in the drawing office, for he was a brilliant mathematician and could apply this knowledge to the solution of practical questions in a manner never before seen in the local world of engineering.

On reaching the age of twenty-three, his apprenticeship and training was completed. His greatest ambition for a long time had been to possess an engineering works of his own where he could be left alone, unhampered, to develop his numerous ideas. In 1825 he opened engineering shops at Felling on the banks of the River Tyne for the manufacture of all kinds of engines and machinery, and, although this was only a small establishment, it gave to him the opportunities he had for long been seeking.

Throughout Isaac Dodds' proprietorship of these works, George Stephenson continually kept him busy either in the manufacture of complex engine fittings or in the production of special designs for locomotive engines and railway machinery. On one occasion he was applied to by Messrs. Wolsey, a great firm of sugar refiners, to try and obtain better results with their sugar boiling plant, which was always failing through



[*From an old print*

GEORGE STEPHENSON

want of an efficient pump to maintain a satisfactory vacuum for any long space of time. He therefore conducted a series of exhaustive tests in order to obtain an apparatus, and in 1830 succeeded in perfecting the first double-acting air-pump, thereby giving great satisfaction to Messrs. Wolsey.

In 1830 Isaac Dodds was engaged as consulting engineer to the Monkland and Kirkintilloch Railway Company, of Scotland, who proposed to use the line between these two towns for some system of mechanical haulage. This railway was situated to the north-east of Glasgow, and was about eight and a-half miles long. It was most difficult to lay-out owing to the restrictions imposed by certain landowners; so, unfortunately, the curves were of small radius and the gradients exceptionally severe. Coming from Kirkintilloch the railway descended with a series of steep inclines of 1 in 50, 1 in 116, and 1 in 120, etc.; the curves were of a radius of 344–400 and 700 feet respectively. Work was commenced in 1824, and in 1826 the line was opened, the event being regarded as an important one, for it was the first public passenger railway to be opened in Scotland.

Until the year 1831 the line was worked by animal power and on the steep inclines by means of stationary engines and the rope haulage system;

in that year, however, the directors decided to experiment with steam locomotives, one of their representatives having seen the wonderful performances of these machines on the Liverpool and Manchester Railway. Isaac Dodds, as the consulting engineer, was directed to make all the designs and arrangements necessary. The stipulations were that the two locomotives built must be capable of hauling a minimum load each of 60 tons at a speed of four or five miles an hour.

Isaac was only too delighted with this opportunity of putting his theories to a practical test, and for several weeks worked early and late to produce what he considered an ideal design. On the completion of the drawings and detailed specifications, the contract for their construction was let to Messrs. Murdoch and Aitken, of Hill Street, Glasgow, who delivered the first engine on the 10th of May, 1831, and the second the following September.

After being subjected to severe tests and running many trial trips, the engines were put to work a regular passenger service.

The cylinders were 10½ inches diameter, with a piston stroke of 24 inches. The steam pressure in the boiler was 50 lbs. to the square inch; the wheels were 3 feet 3 inches diameter; whilst the area of the fire grate equalled about 4 square feet.

One of the many innovations was the metallic packing of the piston, forming the joint between piston and cylinder; prior to this design, pistons were made steam-tight with some kind of fibrous material. As a general practice the piston was turned on a lathe from a solid disc of metal, slightly smaller in diameter than the bore of the cylinder. Pieces of rope or tarred hemp were then wound into a groove cut around the periphery until a tight joint had been obtained. This was always a weak point in the engine, for the hemp packing would never last more than a few days and the replacing meant dismantling the connecting rod and cross-head, the taking off of the cylinder cover, the necessary repairs being made to the piston, and all the joints remaking before the motion members could be re-assembled. According to Gurney in his valuable 'Treatise on Locomotion,' Dodds' metallic packed piston heads were the first of the kind *ever used*, the two engines so fitted for the Monkland Railway had not cost one shilling for repairs to the packing during a period of eighteen months, only a small quantity of oil was required for lubrication; also the economy in labour, the reduction of friction, and the consequent saving of fuel made the invention of wide value.

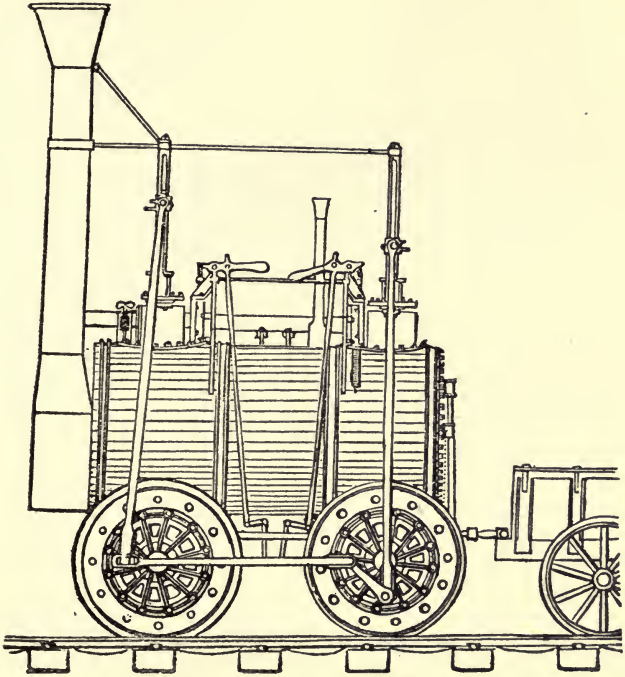
The packing took the form of a pair of iron

rings cut into three segments, a small wedge-shaped filling piece separating each segment, so that the pressure of a small spring behind would tend to expand the circle formed by the segments, and when placed in position inside the cylinders would similarly keep the rings or segments tight against the walls.

The two engines were found to be capable of taking 10 tons more on the level than any engines of the day having similar dimensions. The descents from Monkland to Kirkintilloch were greatly in favour of the engines, as the loads nearly always came from the former place. Hence the return journey with the empty wagons was the heaviest duty they had to perform, yet they had been known to return with fifty empty wagons weighing over sixty tons.

The best tribute received by the designer was that given by the directors of the Railway Company in their annual report to the shareholders on the 1st of February, 1832. This read as follows :—

'Your committee have, as mentioned in last year's report, built two locomotive engines which have been in employment on the railway for nearly six months, and the whole trade from the collieries to Kirkintilloch is now drawn by these machines. The committee, after much consideration, devolved the whole form and plan of these



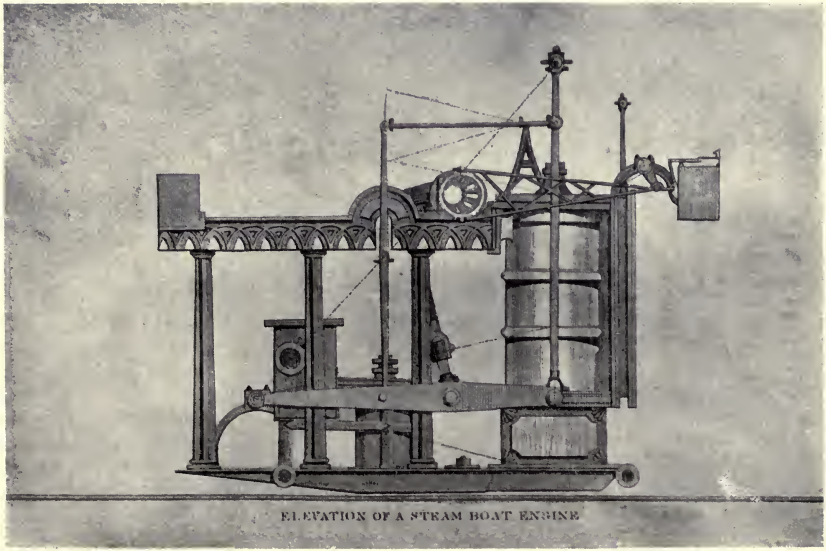
Old Killingworth type Locomotive designed by Isaac Dodds
for the Monkland and Kirkintilloch Railway in 1830.

engines to Mr. Dodds, the Locomotive Superintendent. It was strongly urged by some that these engines should be got from England, and that the improvements of the engines adopted on the Liverpool Railway should be introduced in constructing those for the company.

'On inquiry, however, no certain data could be obtained whereby to calculate what would be the expense of maintaining in repair such improved engines; and it was also ascertained that they were very liable to be deranged when working at the high speeds for which they are calculated. For these reasons the committee devolved on Mr. Dodds the entire responsibility of the planning of the engine, and the result of their confidence has been in the highest degree satisfactory.

'Mr. Dodds, in his plan and specification, adopted none of the recent improvements except that of the copper tubes, suggested by Mr. Booth, giving, however, greater additional strength to these tubes. The contract for making the engines was taken by Messrs. Murdoch and Aitken, of Glasgow, and the committee are satisfied with their performance, except as to the time taken by them in furnishing the second engine.

'The excellence of Mr. Dodds' plan and specification, so far as several months' trial can be considered proof, is most satisfactory, as the



ELEVATION OF A STEAM BOAT ENGINE. 1830

Designed by Dodds for the steam tug *Industry*.

engines have never had one day off work, except on two occasions when injured by the malice or carelessness of certain wagoners on the road. On the other hand, the engines procured from England by an adjoining railway, the " Garnkirk," have been repeatedly taken off the road, on account of needing repairs, etc.'

Twelve months later the next yearly report referred to the engines again in the following terms :—' Since the date of the last report these engines have done all the trade to Kirkintilloch and other places for another year and have not been off for a day or EMPLOYED A SINGLE HORSE TO ASSIST THEM.' They were known to have reached at times a speed of twelve miles an hour : another feature of these engines was in the fitting of ball-and-socket joints to the coupling rods, this being necessary as the wheels were allowed lateral movement to the extent of one inch for negotiating the sharp curves.

The next episode in Isaac Dodds' career was the writing of a book* containing his views on the application of theoretical mechanics to every-day uses. He was assisted in this by his friend, James Hann, whose life-story is one of great interest.

*This work was received with much approbation, and drew general attention to the position of its authors.—*Latimer's Records of Newcastle.*

Hann was born in 1799 at Washington, near Gateshead, where his father was employed as a colliery smith. His acquaintance with Isaac Dodds began at Hebburn Colliery, when they were both in their 'teens,' James Hann being a fireman at the pumping station. Shortly after opening his establishment at Felling, Isaac one day required an intelligent man to work the engines on board his tug boat which he employed on the River Tyne, when he suddenly recollected his friend the fireman of Hebburn Colliery and how he used to watch the black-visaged stoker work out mathematical problems on his shovel with a piece of chalk; he therefore determined to offer the post to Hann, and so wrote off promptly to him.

The reply did not come by letter, but by Hann in person, ready to begin work as soon as required. His duties on board the steamboat 'Industry' were faithfully carried out, but in his spare time he was found, as a rule, pursuing his favourite subject of mathematics, although on one occasion he was met by Dr. Goldsworthy Gurney studying the works of Emerson the fluxionist; Isaac Dodds soon realized that James Hann was not being employed in a capacity worthy of his talents, and he therefore transferred him to the office as a technical assistant.

Whilst working together in close consultation during the long winter evenings, they became joint authors of an engineering text-book called 'Mechanics for Practical Men,' this work being subsequently published by Mackenzie and Dent, of Newcastle-on-Tyne, in 1833.

In 1832, owing to the sale of his Felling Shore establishment and the offer of a lucrative appointment elsewhere, Isaac Dodds decided to leave the Tyne district for Staffordshire, where he had been invited to take over the management of the Horsley Coal and Iron Company.

His friend and assistant, James Hann, also changed his employment, and became a teacher of mathematics in a school at Friar's Goose, near Newcastle. Later Hann became acquainted with W. S. B. Woolhouse, the well-known expert on nautical subjects, and this led to his appointment as a calculator in the 'Nautical Almanac' Office.

A few years later Hann was appointed first writing master and then Professor of Mathematics at King's College, London. Among his pupils was Henry Fawcett. After having a brilliant career, Hann died when only fifty-seven years of age on the 17th of August, 1856. He wrote freely on all engineering matters, published many books, and became the premier mathematician of his

day. He was a great believer in the principle expounded in the following verse:—

> The labour spent on books or arts
> Is both a waste of time and parts,
> If not directed to that end,
> On which man's worth and weal depend.*

* *Mechanics for Practical Men.* By I. Dodds and J. Hann.

CHAPTER III

NUMEROUS INVENTIONS

In 1832 Isaac Dodds, before taking over his new duties, paid a visit to some of his friends in London and on his return to Newcastle, for the purpose of arranging the removal of his household with his wife and child, he heard from George Stephenson that his name had been entered at a competition in that town for the best design of weighing-machine for coals in carts or wagons. So he at once proceeded to Stephenson to get an explanation, telling him that he knew nothing of the subject whatever. Stephenson replied, ' Isaac, thou can'st invent anything ; thou hast three weeks to think it over and make the model in, try for it.'

The model was made and presented half an hour after all the entries should have been sent in ; notwithstanding this omission, his design was accepted, and, as it proved to be far and away the best idea, he was awarded the prize.

In the summer of 1832 Isaac Dodds entered

upon his duties with the Horsley Iron Company,* a concern of a highly progressive type, having a very enterprising and energetic board of directors and a great reputation for its productions; he lost no time in obtaining contracts for the supply of railway material all over the British Isles, thereby largely increasing the firm's business and getting all those advantages accompanying the enterprise of 'moving with the times.' The first engine built under his direction was for a colliery in South Wales, the boiler was carried on two separate four-wheeled bogies, which also carried the cylinders and motion.

In 1833 a competition for the design of a locomotive engine was opened by the Liverpool and Manchester Railway; the best was that received from the Horsley Iron Company, Isaac Dodds making all drawings and designs in connexion therewith. The engine had several improvements and innovations which were entirely original, and had never before been applied to steam locomotive engines. Each frame was made of a solid plate, the horn plates being welded to it, the boiler, although fastened down at the smoke-box end, was fitted at the fire-box end with expansion plates which allowed the boiler to

*The first iron steamship that ever went to sea was built here in 1820–21. It was named 'Aaron Manby' after its constructor.

expand freely or otherwise contract without interfering with the underframe supporting it; a serious difficulty in locomotive construction was in this way overcome. The cylinders were horizontal and fixed outside the frames, and the motion was given to the valve by a return crank working the eccentric-rod to an arc or link controlled by a reversing lever; the position of the eccentric rod in the link varied the valve movement either backwards or forwards as required.

This engine, called the 'Star,' was the first which had the steam passages made larger in area: the maximum valve opening did not exceed 75% of the stroke when admitting steam, but opened to the fullest extent during the exhaust stroke. The designer claimed that 'This was the first engine made with a solid plate frame; the first reversing motion controlled directly by a reversing lever, and the first arc or link motion with fixed centres, used; and also the first with a boiler free to expand on its frame.'

The Anti-attrition Slide Valve

On the 14th of September, 1833, Isaac Dodds was granted Royal Letters Patent for the invention of an improved slide valve of a balanced type. According to the specification, it consisted 'Of the insertion of a wedge-like filling-piece V (Fig. 1),

which pressed on the face of the D valve, thereby causing the valve-face to work truly against the port-face'; the wedge was to be inclined at an angle of forty-five degrees, 'for with this angle the wedge-like piece V can retreat sufficiently to allow the valve to separate a little from the faces against which they apply, in case of great violence of action on the valves when water is accidentally collected in the steam cylinder, or in the event of excessive compression.'

Zerah Colburn, in his comprehensive work on 'The Locomotive Engine,' published in 1871, refers as follows to this invention:—

'Mr. Dodds had foreseen the disadvantage of the great friction of large slide valves under high pressure, and had specified an arrangement (now in favour on some French Railways and known as Plainemaison's valve) for placing the valve in equilibrium.'

To-day modern express engines are invariably fitted with piston valves, but there are thousands yet working with the 'Richardson' balanced valve, which is a mere variation of Dodds' patent system.

Another use for this method survives on all locomotives built even to-day, the rubbing surfaces of axle-boxes and horn plates being adjusted by means of a large steel wedge, a method employed

Fig. 1.—The Anti-attrition Valve
Method of application to horizontal cylinders.

by Dodds in his 'Star' type of engine for the Liverpool and Manchester Railway.

Heavy Locomotives

Having proved so great a success in his design of railway material on behalf of the Horsley Company, the directors urged their ingenious engineer to continue his researches further into the problems of steam locomotion. Dodds therefore communicated with George Stephenson, Joseph Locke, John U. Rastrick, and several others on the question of applying heavy locomotives to the work of hauling loads up the steepest inclines then in existence on a main railway line. He strongly advocated the construction of an experimental engine which he had designed for working 200-ton trains on inclines of 1 in 50. Receiving no support from those sources, he solicited the sympathy and aid of Charles Vignoles, C.E., who, after seeing the drawings sent to him by Dodds, gave his wholehearted approval to the proposition and furthermore made all arrangements with the directors of the St. Helens and Runcorn Gap Railway Company to purchase the engine on its completion, and, if its tests were satisfactorily passed, to use it on the St. Helens incline in place of the stationary engine and rope-winding drum system.

This resulted in an engine called the ' Monarch ' being built at Horsley in sections and then transported to its station on the St. H. and R. Railway. Some time later the ' Monarch ' was erected, and prepared ready to take the road. Isaac Dodds, however, refused to begin the trials until the rope pulleys had been moved, so great was his confidence in the locomotive. Subsequently a start was made and the results far exceeded the hopes or expectations of those present at the trial. The story of this experiment soon circulated around the railway engineering world, and the rope haulage system from that time quickly

NOTE.—It is to be deplored that more details of the ' Star ' and ' Monarch ' are not available; of the former engine and the claims made by Dodds regarding its original features, little is known or recorded. The writer has searched through most public records, but cannot find anything beyond that written in 1866 by J. Guest, F.S.A., who was a frequent contributor to engineering publications of that day. There is no other evidence that the L. & M. Railway had a locomotive called the ' Star ' running on their line between 1829 and 1836: there was, however, a ' Morning Star ' and of course the ' North Star,' but the dates of these engines do not allow of any explanation of the ' Star.' There is no doubt whatever that Dodds was responsible for the design of several historic locomotives of the Stockton Line, also of the L. & M. Railway: his name occurring frequently in connection with railway work in early numbers of the ' Mechanics' Magazine,' and contemporary journals. His statements regarding early locomotive history can be taken by us without much doubt as being reasonably accurate. Mr. Dodds was a man of great integrity, and all who remember him personally without hesitation say that his written comments on this subject can be taken as authentic.

The same applies to the ' Monarch ' locomotive, which worked trains on the ' Sutton Bank ' of the St. Helens Railway. Perhaps some reader can throw more light on the mystery surrounding their existence ?

became a relic of the past. The 'Monarch' was in its way a novelty; it had horizontal cylinders fixed inside the frames, the power from the piston was transferred to the driving wheels through the medium of rocking shafts fitted to the pistons at the smoke-box end of the cylinders; there was also an unusually large boiler and very strong braking gear, consequently the weight of the engine in working order amounted to something over 20 tons, undoubtedly the heaviest machine of its day.

Many works of interest were carried out by Isaac Dodds during the next few years. His best designs were in connexion with railway appliances, but there were other inventions brought out by him with the object of enlarging the scope of his firm's manufactures.

Numerous Inventions

In the latter part of 1834 he made a machine for rolling plate glass, the most difficult part of the construction being the casting and planing of the table, 19 tons in weight, for at this period there did not exist a machine capable of planing so large a surface. It was of the greatest importance that this should be almost 'dead' true; Dodds overcame the difficulty by an ingenious device. He made use of the huge casting to form

the frame of the planing appliance, whilst the tool, clamped securely to the frame or casting, was made to traverse with perfect accuracy the whole surface. This work took more than three months to complete.

The Society of Arts in 1835 awarded Isaac Dodds a silver medal for 'an improved parallel motion' (Fig. 2), which he patented during July of that year, in connection with another patent for wood-working machinery. This improvement he applied to machinery for cutting slots in timber or to engines of the 'vibrating pillar type' for guiding the motion of the piston-rod in place of the cross-head and guide-bars.

On the authority of James Hann this parallel motion was applied with much success to marine engines. In his contribution to 'Mechanics for Practical Men' he writes:—'In steam-boat engines, a parallel motion may be put on so as to make the air-bucket, piston and feed-pump rods all move in the same kind of a line, that is approximately to a straight line. . . . Mr. Dodds had built a steam-boat engine on this principle, which is the first I have ever heard of.'

Several marine engines were constructed by Isaac Dodds at his Felling Shore Engineering Works previous to his departure for the Horsley Works appointment; the first of this type of

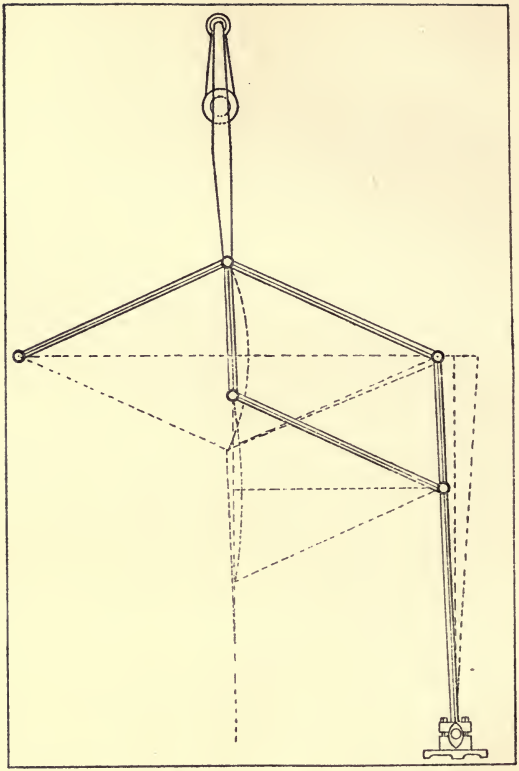
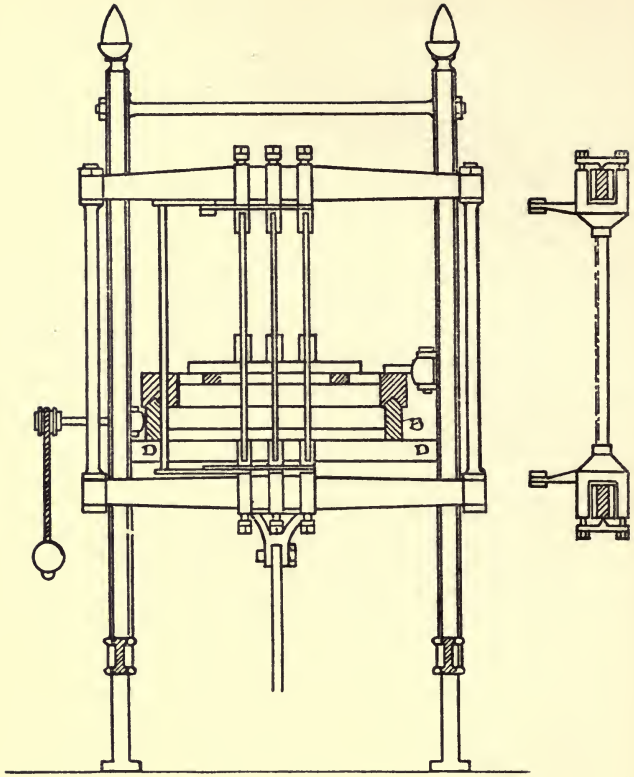


FIG. 2.—Parallel Motion as applied by Dodds to Steamboat Engines, etc., 1826–1835.

engine, illustrated in this article, was fitted to the steam tug-boat 'Industry,' which was used at that time for towing vessels on the River Tyne, and where, it will be remembered, Hann was originally employed as engineer.

His attention was next drawn to woodworking machinery of various kinds through a London firm of coopers and carriage manufacturers, Messrs. Hooper and Co., one of the foremost concerns of that day, who had a strike amongst their workmen threatening serious loss of trade and delaying the execution of several large and important contracts. Messrs. Hooper, having previously dealt with the Horsley Company to their entire satisfaction, invited the engineer and manager, who was then in London, to try and devise some means of sawing barrel staves and similar wood articles by machinery and thereby defeat the strikers. Isaac Dodds therefore undertook to produce a design within a few days; however, after a short time with his pencil and notebook, he returned to Messrs. Hooper's office with a sketch of a new type of saw which he thought would do the required work. He proposed to them that he should return to Horsley Works and complete the designs, then immediately proceed with its construction. The suggestion being approved, Dodds returned to



SECTION

FIG. 3.—The first Curvi-linear Sawing Machine. The method of using a pattern at the side to guide the cutting tool is widely employed to-day in connection with milling-machines.

the Works. He there made out the drawings and details of the first curvi-linear sawing machine ever made for practical purposes (Figs. 3 and 4). In the Patent Specification No. 6755, dated the 29th of January, 1835, he states:—'I claim as the particular feature of novelty invented by me in connection with a sawing machine for cutting and shaping wood and other materials, first, the adaption of the transverse railways or ribs, DD, upon which the frame with the material to be cut may be slidden laterally; secondly, the longitudinal railways or ribs BB, upon which the carriage for conducting the articles to be cut is gradually advanced to the saws; thirdly, the attachment of a model or pattern T, for the purpose of determining the forms of the pieces to be cut by the action of the saws; and, fourthly, the manner of mounting the saw blades so as to enable them to turn into the correct cutting lines.'

This machine was completed in slightly more than three weeks, a very rapid piece of work for that time of day, and particularly as the working drawings, patterns, castings and a certain amount of delicate steel tempering had to be carried out. When finished the machine was sent off by road to Messrs. Hooper's works in London, its trial producing results of a highly satisfactory nature

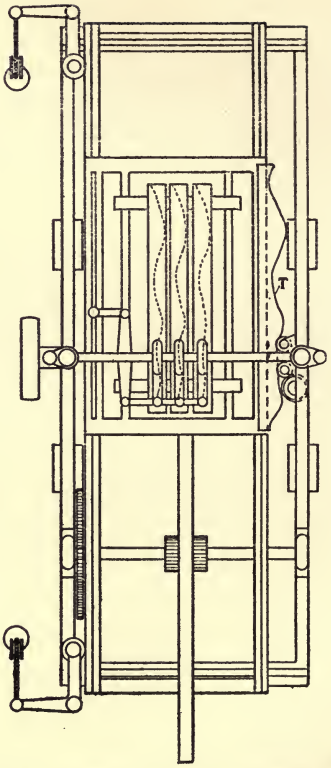


FIG 4.—Longitudinal Plan, Curvi-linear Saw.

and many times multiplied the output of their manufactures formerly turned out by hand.

The Fusible Plug

In the latter part of 1835 the Society of Arts awarded Dodds a second medal for an invention for the prevention of boiler explosions. The following description is given from the 'Mechanics' Magazine,' 1836-1840 :—' In some steam boilers a hole is made at the bottom and is afterwards filled up with a plug of lead or fusible metal in order to serve the purpose of a safety valve; for by duly proportioning the ingredients of which the plug is composed, its melting-point may be lowered from that of 612° F. (the temperature at which pure lead is fluid) to 212° F., the ordinary boiling-point of water, which is more than sufficient to melt common fusible metal composed of eight parts bismuth, five parts lead, and three parts tin.'

'Mr. Dodds objects to the usual position of such safety plugs because, being inserted in the lowest part of the boiler, it will remain covered with water, even when so little is left in the boiler as to allow part of the bottom and sides to be uncovered and therefore liable to become red hot. Now, since the plug in this position cannot acquire higher temperature than that of

the water by which it is covered, it may continue unmelted while the steam and other gaseous contents of the boiler are accumulating until an explosion takes place. This hazard, in the opinion of Mr. Dodds, will be prevented by placing over the hole in the bottom of the boiler a cap of iron of such a height that its top shall be left uncovered while the bottom of the boiler and those parts which are exposed to the direct action of the fire shall still be left under water.

'The top of the cap is to be perforated by a hole which is to be filled up by a plug of fusible metal. When, therefore, from defect in the feeding apparatus, or from neglect on the part of the engineman to work the supply pump, the water in the boiler is so far evaporated as to be a little below the top of the cap, the heat, not being conveyed off by the water, will melt the plug and the steam will be discharged through the hole into the fire.'

This well-merited award could not have been earned by a better invention, for the improved type of 'fusible plug,' as introduced by Isaac Dodds, has since been the means of preventing thousands of disastrous boiler explosions and consequent loss of human life.

He received further recognition from the same Society for a new method of casting light railway

wagon wheels which obviated cutting the wheel naves formerly necessary because of contraction during the process of cooling.

The many improvements brought about by him obtained for the Horsley Ironworks considerable fame in engineering circles, the trade increasing by leaps and bounds until it became one of the most prosperous concerns in the country. Also the fact that their Manager and Chief Engineer was a personal friend of men like Stephenson, Wood, and others contributed largely in their favour when competing for numerous contracts for the supply of railway material particularly.

The Dublin and Kingston Railway

In 1834 he supplied, at the request of Charles Vignoles, the engineer of the Dublin and Kingston Railway, detailed designs of the rolling-stock for that line. This was the first railway to be constructed for the carriage of passengers in Ireland and, although originally promoted in 1828, it was not opened until 1834.

Locomotive building at that time had not been commenced in Ireland, and the problem of executing repairs to engines was one of some difficulty, and it was necessary for the engineer to make allowances for this in his designs. After some

time of careful thought Dodds drew up plans and specifications of a series of powerful locomotives and some very serviceable rolling-stock. He solved the question of repairs and maintenance by resort to standardization; parts of engines, passenger carriages, goods wagons, wherever possible, were made interchangeable; springs, wheels, axles, bearings, brake gear, etc., could be taken from a wagon and fitted to either carriage or the carrying wheels of the locomotives. The simplicity of design and facility of access had been aimed at particularly, and he was completely successful in his endeavours. His ideas were developed by Charles Vignoles, and, although the first engines were obtained from Messrs. George Forrester and Co., and the Sharp, Roberts Coy., subsequent orders for new locomotives were built on Dodds' principles. The carriages and other rolling-stock for the line were constructed by the well-known firm of Melling and Co., of Manchester, from drawings and specification carried out by him: according to 'A Stranger's Guide Book to the Irish Metropolis,' 'The railway coaches of the first and second class may be almost called elegant; the third class carriages are superior to those in use on the English Railways, and all are covered. Trucks are also provided for conveying gentlemen's carriages, etc.'

The best coaches were fitted with spring buffers, this being the first occasion when the utility of the appliance was recognized. Other spring buffers were invented by the Railway Company's Secretary, Bergin, who attempted to combine a spring draw-bar with a central spring buffer. The plan was widely advertised, but, owing to its complexity, it never proved reliable under service conditions.

CHAPTER IV

A CHECK TO A SUCCESSFUL CAREER

For five years Dodds carried on his successful work with the Horsley Iron Company. In addition to those inventions already described, he produced a vast number of other mechanical designs. His improvements to firearms were of great importance, for his repeating pistol was a distinct innovation as far as such weapons were concerned; he made a machine for boring out the barrels of heavy cannon, which was a great advance over old methods and soon found a place in the largest ordnance and armament factories of the day. He also patented twin and multi-barrelled guns and cast, on one occasion, four large guns with barrels radiating from a central, common breech piece 90 degrees apart. These remarkable weapons were made by the Horsley Company in great quantities, and sent to France, Germany, and other European nations.

Dodds also succeeded in improving the workmanship and consequent accuracy of machine

parts, for at that time the quality of most engineering productions was very poor, this low standard being largely responsible for the general distrust and preference for other methods than mechanical. Steam-engine failures due to defective material and bad workmanship frequently caused disaster and loss of life, the progress of mechanical science being seriously hindered because of unreliability of almost all classes of machinery. By the introduction of carefully designed standards into his workshops and the provision of adequate detailed drawings, Isaac Dodds was able to accomplish improvements of untold value.

At the age of thirty-five, Dodds was numbered amongst the most eminent engineers of the day, his advice and assistance being sought by the ablest members of his profession. George Stephenson, although surrounded by a most brilliant circle of engineers, who could invariably be called upon to supply him with a solution to the hardest of problems, frequently consulted him and never failed to acknowledge his inventive genius.

This remarkable career was suddenly checked by an accident which took place in the workshops of the Horsley Ironworks in 1836. A splinter of iron struck his right eye, so damaging it that its immediate removal was necessary to prevent total blindness.

For many months Isaac Dodds remained in retirement as the result of this unfortunate accident, and it was for long feared that the sight of his left eye would also be lost; but after several months' rest, following a very dangerous surgical operation, he began to recover, and with this improvement his eye also got better.

In the early part of 1837 he was able to resume work of a light nature, and he therefore informed various professional friends of his intention; several eminent engineers were anxious to secure his services, among them being Joseph Bramah, whose father invented the Hydraulic Press, who made him a liberal offer of a partnership in his firm of consulting engineers, mentioning also that he should not be required to look on paper.

He was, however, induced by his brother-in-law, John Stephenson, the great railway contractor, to take charge of the construction of the Sheffield and Rotherham Railway (Fig. 5) and a portion of the North Midland line, which had been successfully tendered for and already commenced. Early in that year Dodds moved to Rotherham, a town of much importance, as it was the centre of the South Yorkshire coalfield, and there took up his residence.

The first event of importance which occurred to Dodds and his associates in this district was

the serious outbreak of rioting which took place between the English and Irish navvies employed at work on the new lines.

The beginning of the railway era in this country created a demand for an enormous number of labouring men, far more than was locally obtainable in fact; this deficiency was quickly remedied by the influx of Irish labourers who came over from their country in thousands. This was regarded by the English navvy as a trespass on his preserve, so he determined to prevent any

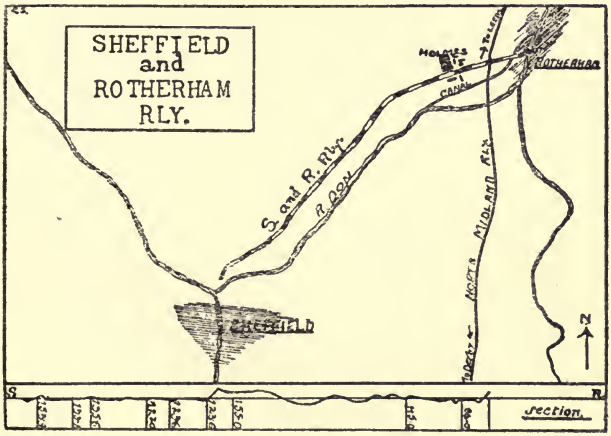


FIG. 5.—The Sheffield and Rotherham Railway. 1838.

further immigration taking place. Quarrels of a minor kind were the order of the day, and each side, apart from worktime, left one another severely alone. This state of affairs continued on the North Midland, as it did elsewhere; but the struggle which had been for long expected finally began in 1838, and, strange as it may seem, the trouble originating on these lines spread like wildfire throughout the country, and wherever English and Irish were employed together fierce battles were fought. This outbreak began while the navvies were at work on a section of the line between Swinton and Darfield, on the North Midland; a quarrel arose between an English and Irish navvy, and they at once resorted to fisticuffs. After damaging each other almost beyond physical recognition, the Irishman was beaten; his second, however, mad with rage at his countryman's defeat, rushed at the victor and delivered him a heavy blow on the head with the helve of a pickaxe, rendering him unconscious. At this moment the situation was saved and improved considerably as the result of strong measures taken by those in charge of the men, and for a time common-sense prevailed over angry passions.

The following day, however, there was a simultaneous movement on the part of the English

VIEW OF THE TERMINUS STATION AT ROTHERHAM

Sheffield and Rotherham Railway. 1840.

navvies; armed with various weapons of their calling they attacked the Irish, who were working between Cudworth and Sheffield, and proceeded to drive them in the direction of Rotherham. The Irish, who were inferior in numbers, had no option other than speedy retreat. As they drew near to that town, their forces increased, and, arming themselves with hedgestakes, they made a show of resistance, and for some considerable time a sanguinary encounter was fought.

Hearing the news of this trouble, Isaac Dodds and John Stephenson, who were at the time inspecting the works together, proceeded as fast as they could to the scene of conflict. They arrived just as the Irish were in the act of being annihilated, and at once forced their way into the midst of the antagonists, and succeeded in separating them. John Stephenson ordered the Irish into the nearest station yard, some distance away, whilst Isaac Dodds spoke to the English navvies and pointed out the seriousness of their action. The Irish allowed themselves to be led away by Stephenson, but some of the English ringleaders followed them as far as the station. On arrival here one of these men rushed at the peace-maker and struck a heavy blow at him with a bludgeon. Isaac Dodds, who was standing near by, however, as quickly seized the aggressor

and thereby prevented the blow from reaching his brother-in-law.

Riots of this kind were afterwards frequent throughout the land and continued until late in the 'forties,' and, although bitter encounters no more took place, for many years after the Irishman was strongly resented by the English navvy.

'The Old Cutler'

The directors of the Sheffield and Rotherham Railway appointed Isaac Dodds their Locomotive Superintendent and Resident Engineer in the early part of 1838. They instructed him to arrange for the purchase and manufacture of the necessary rolling-stock, including a series of powerful locomotives capable of hauling the heaviest loads up the steep grades on the Western portion of the line.

Two of these engines he ordered from Robert Stephenson's celebrated factory at Newcastle, two others of his own design from the firm of Davy Brothers, of Brightside, Sheffield, and some time later obtained two from the Railway Foundry, Leeds.

The delivery of these engines became a matter of some concern, and, in order to avoid the possibility of disappointment on the opening day, Dodds proceeded to make a locomotive in a

small workshop adjacent to the Company's line near Rotherham. This engine, known some years afterwards as the 'Old Cutler,' was a six-wheeled engine with a single driving wheel of the 2–2–2 type. Its boiler had the haystack firebox then in vogue, and was attached to the frames in a manner peculiar to this engineer's designs, i.e. fastened down at the smokebox end only, but at the firebox end being allowed to expand or contract freely according to the varying temperature; a small plate or bracket bolted to the frame preventing any vertical movement of the boiler. The usual horsehair buffers were dispensed with, and an entirely new method was employed; for the first time in the history of locomotive construction, spring side-buffers were given a trial, and the resulting economies in repair and upkeep of engines so justified the designer's contentions that the practice became general. Although only a small engine, the 'Old Cutler' did wonderful service for over twenty-five years, costing very little in repairs throughout her career, and it was not until the year 1875 that she was taken off the road and scrapped.

The 'Old Cutler' was fitted with one of the earliest forms of valve gears which provided for the expansive working of the steam. Up to the year 1838 the reversing of a locomotive engine

was accomplished by a fork-and-catch arrangement generally known as the 'gab motion,' the valves were driven by either of two sets of eccentrics placed in opposite positions to each other, one set driving forward and one backwards; when reversing the engine, therefore, the driver had to disengage the connecting rod from the 'forward eccentric' and attach it to the 'backward' eccentric. This was a slow and tedious operation and required considerable skill to accomplish successfully. John Gray, of the York and Newcastle Railway, had a little earlier devised a method for simplifying valve gears by the introduction of the 'horse-leg' motion, thereby reducing coal consumption over 30%, and although it was a vast improvement on existing gears, yet some very serious objections prevented its general use. It was exceedingly complicated, and, owing to the large numbers of joints and its indirect action, the slightest wear rendered it unreliable. In his design of 1838 Dodds made the first successful reversing motion; the slide-valve was driven by means of a single eccentric, made capable of being placed in any required position relative to the crank by means of a double wedge sliding along the axle so that in its motion the eccentric moved into successive positions required. The sliding wedges were

held in place by the notches of the quadrant and lever in the cab. Writing of this invention, in his book on ' Locomotive Engineering and the Mechanism of Railways ' published in 1871, Zerah Colburn makes a very deep and interesting study of its action, but apparently considered it only as set down or described in the Patent Specification taken out by Dodds in 1839, whereas its full value as an apparatus for working steam expansively was clearly demonstrated by engines used on the Sheffield and Rotherham Railway. The importance of expansive working was realized by him as far back as 1833, in his design of the ' Star ' for the Liverpool and Manchester Railway, wherein the motion was given to the valve by means of a return crank, actuated through an arc or link, by an eccentric which was made to fasten on the driving axle and assume two positions either for forward or backward working. The arc or link provided a means for varying the valve's travel, thus obtaining an adjustable cut-off. Commenting on the ' wedge motion,' Colburn in his work says :—' Dodds' wedge-motion eccentric . . . has been adopted as a variable expansion gear in a considerable number of modern locomotives, among others in some very heavy tank engines designed by the late Mr. Brunel for the Vale of Neath Railway. In his

specification Dodds referred to variable expansive working. . . . The practical qualities of Dodds' wedge-motion eccentric have been found to be reasonably satisfactory, and it is not improbable that it may come into extensive use in future practice. It takes up very little room under the boiler, has few joints, is cheaply fitted, and answers all the geometrical conditions of valve movement fulfilled by the link motion. It has been objected to in some cases as liable to jam between the wedges and eccentric, and as difficult to reverse with steam on. With well-fitted surfaces, proper attention to oiling, and with properly proportioned reversing apparatus, these objections would be obviated.'

The Stephenson-Howe link motion was not brought into use until October 15, 1842, when Robert Stephenson and Co. delivered their No. 359 to the North Midland Railway Co. We must, therefore, credit Isaac Dodds with being a pioneer of one of the most important questions in the science of steam engineering, for his invention was in use four years before the Stephenson link gear was introduced.

CHAPTER V

THE HOLMES ENGINE AND RAILWAY WORKS

SOME little time before the Sheffield and Rotherham Railway had opened, Isaac Dodds, with the assent of his directors, decided to find a site for a factory where he could, on the completion of the railway, commence the manufacture of railway machinery and appliances. After examining all the available land in the neighbourhood of the railway, he eventually made up his mind to purchase the soap and candle factory of Messrs. Dodd and Layton at the Holmes, a small but important industrial locality near Rotherham, and a short distance from Sheffield. There he found a good factory with splendid workshops, good roads in and around the works, whilst a satisfactory water supply was also to be obtained, for the River Don, canalized, flowed past only a few yards away. He quickly obtained a supply of engineer's machinery, and had the factory in working order by the time when the engines he had designed for the Sheffield and

Rotherham Railway began to arrive in pieces ready for erection by his workmen.

All the engines used on this railway for several years afterwards were built and repaired at these works, and the thorough way in which the work was executed soon got for Isaac Dodds a great reputation as an engine-maker, thus proving him a fit successor to the great ironfounders who, on the same ground and in the same workshops, twenty years before, had by casting the spans for the great Southwark Bridge achieved what was then considered an impossible task. A few words here about these great ironfounders may serve among some readers to keep their memory alive.

The firm of ironfounders of Joshua Walker and Co., of Holmes, near Rotherham, Yorkshire, was at the beginning of the nineteenth century the greatest in our Isles. It was commenced by Samuel Walker about 1745 in a very small way, Walker at that time being a boy of seventeen years of age. He, however, soon made his business a thriving one; by working long hours and living a very meagre existence he realised enough capital to increase his trade. He quickly made a reputation for himself as an ironfounder, the progress of his business being subsequently astonishing, and as the result of

this he decided to transfer his workshops to the Holmes district, where coal and ironstone could be obtained in abundance.

In the course of time the business developed into a huge concern, for such as it was in those early days when the Iron Age had not arrived, and, from being a humble worker in a tiny workshop by himself, Samuel Walker lived to hand over to his children a business with a world-wide reputation, financially powerful and employing several hundred highly skilled men; furthermore, practically the whole iron trade of Britain was a monopoly in his hands.

Under the control of Samuel Walker's son, Joshua, the firm's progress and reputation was enhanced. They cast nearly all the cannon used by our Armies in the Peninsular War, and made the castings for the great bridges at Sunderland and Yarm.

The death and retirement of several partners gave signs of a forthcoming end to their victorious labours, but not before their greatest work had been accomplished, for in 1815 they took the contract for a huge bridge to be erected over the Thames at Southwark.

This bridge was supposed to have been designed by the Rennies, but was actually designed, in the modern sense, by the makers, for the design was

largely governed by the problems involved in manufacture. It had three spans consisting of cast-iron arches, the two side arches were of 210 feet span, while the great arch in the centre measured 240 feet. The prospectus issued by the promoters stated that 'in its structure it is not equalled in magnificence by any bridge in Europe.'

The bridge was looked upon by the scientific world as the great wonder of the day, and when the huge castings forming the arches were being fitted together in a field, where subsequently Isaac Dodds opened his engineering works, thousands of people came from miles around to see and wonder at this marvel of engineering skill. The largest casting in the bridge weighed nearly twenty tons, and it was everywhere admitted that Messrs Walker and Co. was the only firm in Europe capable of producing so great a casting.

The execution and erection of the bridge was placed under the superintendence of William Yates and his son; together father and son watched its growth stage by stage until every detail and part fitted with perfect accuracy. When completed in the workshops, all the parts were marked so as to facilitate erection in London. Special ships were chartered for the large castings, and on arrival in London the bridge was found to fit together without the slightest difficulty,

and it was never necessary to send to the foundry for duplicate parts. The workmanship was perfect. Great credit was bestowed upon Messrs. Walker and their manager, William Yates, and they were feasted by all the most notable scientific associations of the day.

The works at the Holmes were closed down on the completion of the Southwark Bridge, as there came a time of great trade depression, ' for when Peace visited Europe in 1815, and waving her olive branch scattered plenty and prosperity over the nations, she frowned upon those who had forged the engines of war, smote down their proud looks, and oft-times scattered their possessions.' The numerous managers and workmen were subsequently scattered throughout our country, many of them became engineers of fame. William Yates, Junior, was undoubtedly the first to propose the construction of the Liverpool and Manchester Railway, for at the opening dinner, when somebody rose and proposed the health of Mr. William James as the promoter and originator of the line, he at once disclaimed the honour and, in a speech, stated that the credit should be given to one man only and that was William Yates, who, he said, was absolutely the first to suggest and advocate the construction of this historical line.

Thomas Paine, the notorious agnostic, was employed on the bridge work by Messrs. Walker, and while engaged in his work at the office introduced many improvements into bridge building. It is said that in his spare time at the Works he wrote the 'Age of Reason.'

From 1838 to 1845 Isaac Dodds was solely occupied in the improvement and manufacture of railway appliances; as soon as the difficulties experienced in getting the Sheffield and Rotherham Railway into working order had been satisfactorily smoothed, he turned his inventive faculties on to designing small tools and machines for facilitating the special operations involved in railway construction. The results of much time, thought, and trial produced the 'Punching Bear,' the 'Punching and Shearing Machine,' and the 'Jim Crow,' as now used by plate-layers.

Among the numerous improvements in railway machinery made by Dodds was the locomotive engine turntable, pivoted in the centre and supported at each end, should any weight fall there, by means of two wheels running on the track of a rail forming a circumferential ring in the bottom of the turntable pit. Hitherto the turning of an engine had only been carried out by slow and laborious methods, in many cases the engines

had to be taken along a circular track and then be switched on to the main line again. Many attempts had been made previously to construct a satisfactory appliance for reversing railway engines and vehicles, but these were of a complicated nature and so were totally impracticable.

In his design Dodds set out to achieve the desired object in a simpler way. Instead of employing lifting machinery actuated by hydraulic power, he placed a line of rails on a strong girder made of timber and metal. This girder was carefully balanced at its centre where it was supported and carried with a cup-and-socket arrangement, the ends, as previously described, were supported when the table was out of balance by wheels running on a circular track of rail; an engine-man could thus move the heaviest weight on the table single handed. Little improvement has been made on this method, even at the present time, although originated over eighty years ago; for at any important railway centre it is possible to see nowadays a huge engine with its tender, weighing perhaps a hundred tons or more, being revolved on the turntable by its fireman with comparative ease.

The original turntable was installed by Dodds a short time after the Sheffield and Rotherham

Railway was opened, and as no patent had been taken out it was quickly copied by other engineers and soon became the standard method for turning railway vehicles. In 1839 and 1840 there were two sets of turntables in use on this railway at the Sheffield terminus, and another set at Rotherham.

The Volute Spring

On one occasion Isaac Dodds was travelling to Derby with Robert Stephenson and W. H. Barlow, the engineers, in the early forties, when a simple incident took place resulting in the discovery of the volute or conical form of spring. After a long period of conversation, a member of the party handed round a case of cigars, whereupon Isaac Dodds obtained a piece of paper for the purpose of lighting them, and twisted the paper spirally into a spill. Having supplied this want, he unconsciously held the remaining portion of the spill between his thumb and forefinger, springing it backwards and forwards for some little time. He then released the pressure suddenly in order to let it drop, when the spill shot out of his grasp like a spring. He was astonished at this, and it struck him that a piece of steel so coiled would make a most satisfactory buffer for railway work. On his return to Rotherham the following day

he went to the Holmes Works and gave orders for two springs of the conical type to be put in hand at once. Two large buffers were made, one of flat steel, the other of round steel with sides flattened. These when completed were fastened to a beam and fitted on to shafts of iron so that the pressure caused by a shock would be borne centrally; further, a large flat plate riveted on to the end of the shaft distributed the shock along all the coils as the pressure became greater. These improvised buffers were then fixed on to the station buffing stops at Rotherham. Needless to say, they proved superior in every respect to the ordinary 'dead' buffing beam and were soon put in place of the old system throughout the Sheffield and Rotherham Railway.

An interesting story regarding the invention of the volute spring was told to the writer by an old workman of the Holmes Engine and Railway Works. This story was apparently accepted by old tradesmen of the spring trade as the true origin of the invention and its subsequent wide adoption by engineers.

Early in 1840 a number of spring smiths were standing round a table in a Sheffield workshop studying a problem in connection with the making of a spring for railway work. The spring, according to the specification, had to be of more than

ordinary strength, but not of greater dimensions in breadth or width. This stipulation the smiths after several attempts failed to satisfy, and consequently the whole brain power of the workshop was centred on this one problem. Their reputation as clever tradesmen was at stake, yet up to the moment in question they had not succeeded in getting nearer the solution of the difficulty. Whilst they were engaged in discussing the subject, unseen, some strangers entered the shop, and seeing the group of workers engrossed in a knotty problem, crossed the floor to see what was happening. One of the strangers observed to his companions that the spring in question, which had been made of the ordinary carriage type, was totally unsuitable for the purpose, owing to its lack of resilient qualities. One of the smiths, overhearing this remark, turned to the speaker and asked for his advice if he knew anything of the subject. The stranger addressed replied, 'Yes, the only satisfactory way out of the difficulty is to use the type of spring adopted by us for the railway buffers on the Sheffield and Rotherham Railway. They will not take up a quarter of the space and can be more easily made.' He then proceeded to sketch out those springs known to-day as the conical and volute forms.

The stranger speaking was Isaac Dodds, and the head spring smith was a man whose name is still in use, describing one of the greatest engineering firms of to-day. Dodds never patented the spring, but others soon applied for the patent, two of the patentees obtaining huge fortunes by its manufacture and incidentally making themselves famous in the history of inventions.

This incident is not mentioned with any intention of detracting from their reputations or good works, but with the object of giving an account of the origin of the spring, as generally accepted by workmen in that trade some sixty or seventy years ago, to a wider public who can credit the story with the truth it appears to justify.

In 1839 Dodds became associated with a most ingenious engineer in the personage of William Owen, who had made a great reputation as a producer of heavy forgings—the steam hammer not having then been invented—and having many inventions to his credit. Together they applied for and were granted Letters Patent for no less than six valuable improvements in railway machinery.

These were classified as follows :—

(1) In novel methods of constructing railway wheels of wrought iron.

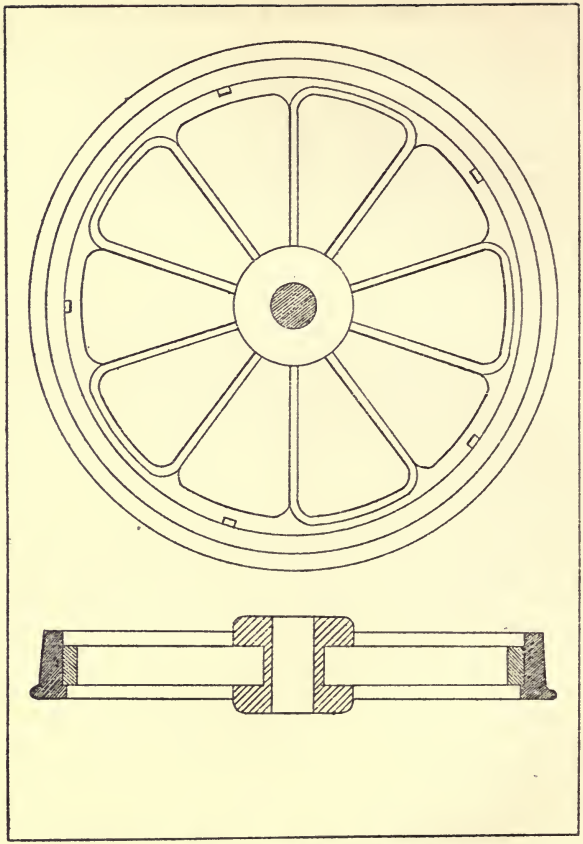


FIG. 6.—Dodds' and Owen's patent wheel for wagons, showing method of construction.

(2) In an improved method of forming cranks and crank shafts.

(3) In a new mode of coupling carriages and other railway vehicles together in a train.

(4) In a novel method of applying springs to the buffers of railway vehicles, for the elastic supports of such vehicles, and for preventing the lateral motion of such vehicles being transmitted to the carriage or vehicle.

(5) In improvements to the working parts of a locomotive engine.

(6) Novel methods of working rail switches.

The first two items refer to William Owen's method of making those parts in question in a way which would produce a satisfactory article and avoid the difficulty of intricate welding, his system being clearly revealed in Fig. 6.

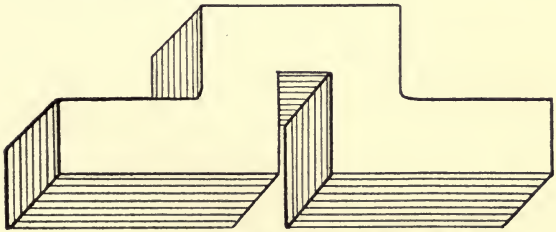


FIG. 7.—William Owen's method of making large forgings. The crank here shown is formed of plates first cut to shape and then welded together.

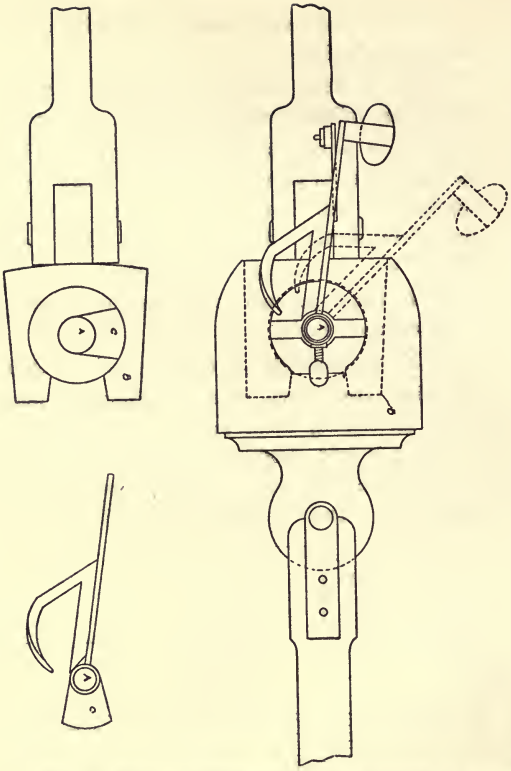


FIG. 8.—Safety Coupling invented by Dodds in 1838.

The remainder of the Patent Specification was devoted to the various inventions of Isaac Dodds. In No. 3 the carriages were to be fitted with an ingenious device for slipping the coach in the case of derailment, for, if the carriage moved laterally too far either right or left, a pin passing through the draw-bar would be automatically withdrawn, and thus allow the couplings to separate, leaving the derailed coaches behind. (Fig. 8).

No. 4 introduced a new type of spring buffer with the object of getting springs of different elastic strength acting in conjunction at the same time (Fig. 9). The system might also be applied to the supporting springs of a vehicle. This improvement consisted of the substitution of a single strong helical or coiled spring by a number of smaller springs of different length and size. These springs abutted upon different steps or stages in the extreme ends of the buffers, the longest springs being placed between the steps furthest apart and the shorter nearest each other. The effect of this arrangement was to produce a more sensitive elasticity than could be obtained with a single spring. The latter part of No. 4 was for the absorption of shocks and vibration usually transmitted to a carriage by the lateral motion of the wheels. This was effected by fixing

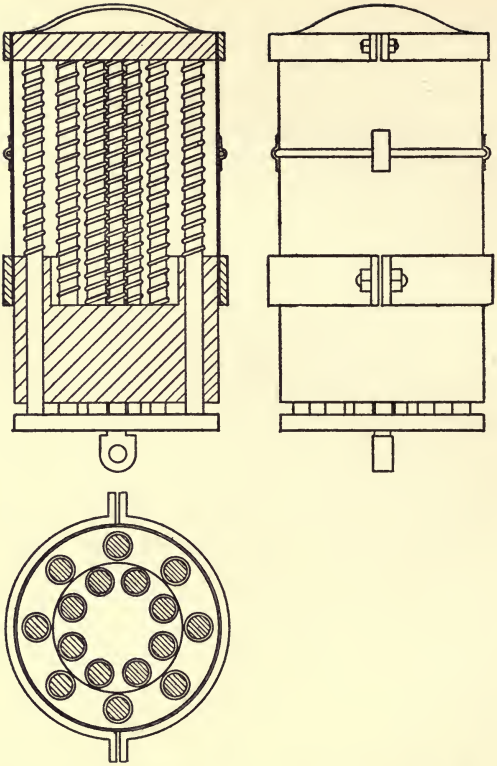


FIG. 9.—Spring Side Buffers invented about 1835, and patented some four years later. Probably the earliest example of the modern buffer ever used.

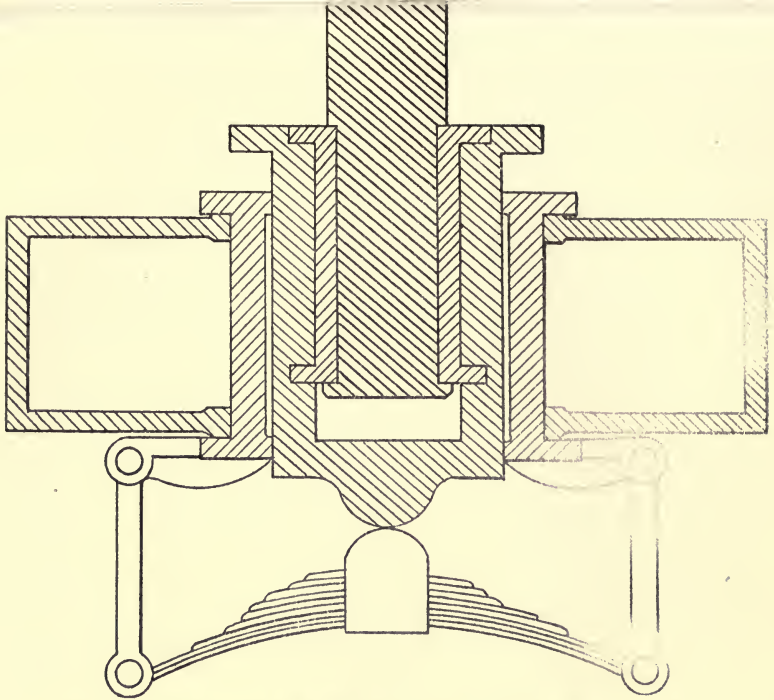


FIG. 10.—Lateral Shock Absorber applied with much success by Dodds to railway carriages.

a spring at the extremities of the axle abutting the ends, so that any lateral movement of the wheels, instead of jerking the carriage violently to one side, would first act on the spring or shock absorber, and any pressure on the wheel flanges would thus be gently and evenly transmitted to the carriage (Fig. 10).

No. 5 was by far the most important part of the patent as affecting locomotive history, for in it was described the first practical valve gear; several others had appeared at about that time, but they were not of a satisfactory nature. Gray's horse-leg motion, patented in 1838, never proved its value, as its movements were too complex for use as a sound mechanical appliance; the 'WEDGE ECCENTRIC MOTION,' as set forth by Dodds, had been in use for nearly two years when this specification was accepted. It was a very simple design, the action of the gear being direct without the use of any intermediate mechanism, all movements being effected by means of the arrangement for placing the eccentrics in any desired position relative to the crank, as previously described.

The reader will observe, in the diagram (Fig. 11), its great simplicity of construction and its suitability for use in the locomotive engine. Dodds also describes in his specification the

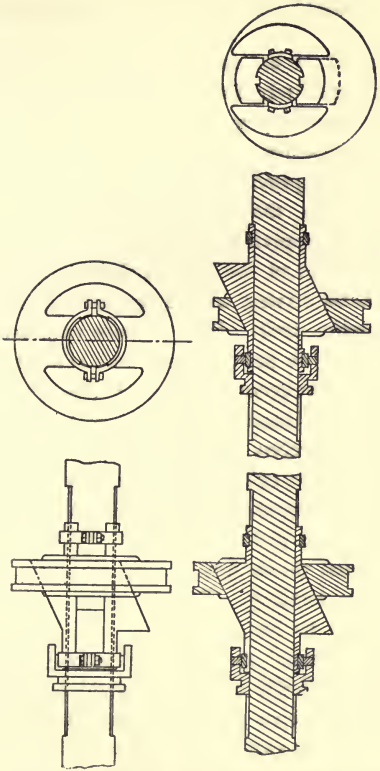


FIG. 11.—The Wedge Eccentric Motion as introduced by Isaac Dodds in 1838 on the Sheffield and Rotherham Railway. It was first put on a locomotive called the 'Old Cutler,' and was the first successful variable valve gear.

employment of an auxiliary valve for expansive working separately from the main valves. This, however, was only an attempt to give full scope to the application of the wedge eccentric motion.

In No. 5 he provided for novel cylinder arrangements, or, in the words of the specification, 'consists in applying the power of two or more shafts or axles of the wheels, thereby making all these wheels driving wheels and thus doing away with coupling rods. Two or more cylinders may be used, but we prefer three; one cylinder inside under the smokebox driving to the centre pair of wheels, the other two cylinders being outside either the firebox or smokebox, driving the leaders. Three cylinders can be placed side by side in the smokebox, two cylinders driving one shaft and one with the other.' (Fig. 12). He also included the design of a light built-up piston within this heading. This is clearly understood by reference to Fig. 13.

No. 6 claims for the self-acting switches invented by Dodds for the Sheffield and Rotherham line and fixed by him during the early part of 1839. These switches are shown in Fig. 14, and according to opinions of engineers, expressed many years afterwards, were of great advantage over the roughly improvised 'turnouts' then in general use. They were widely adopted on British lines.

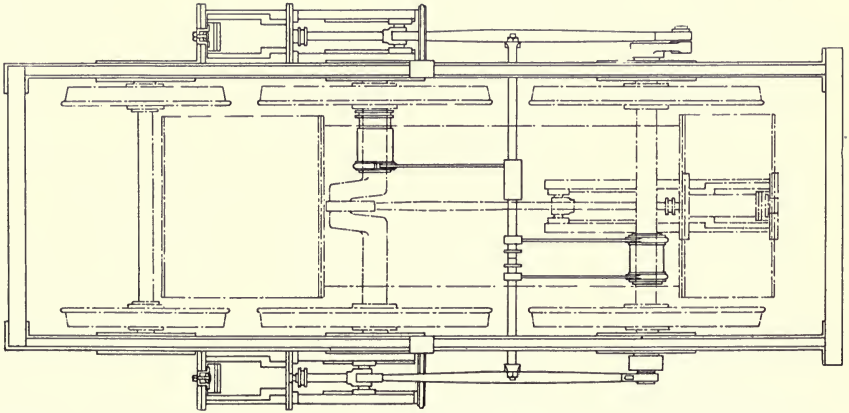


FIG. 12.—THREE CYLINDER LOCOMOTIVE (PLAN)

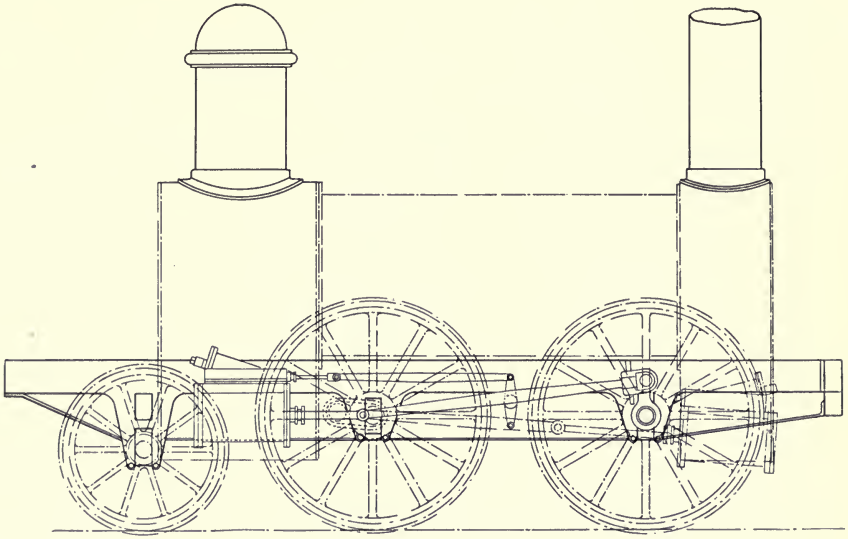


FIG. 12.—THREE CYLINDER LOCOMOTIVE (ELEVATION)

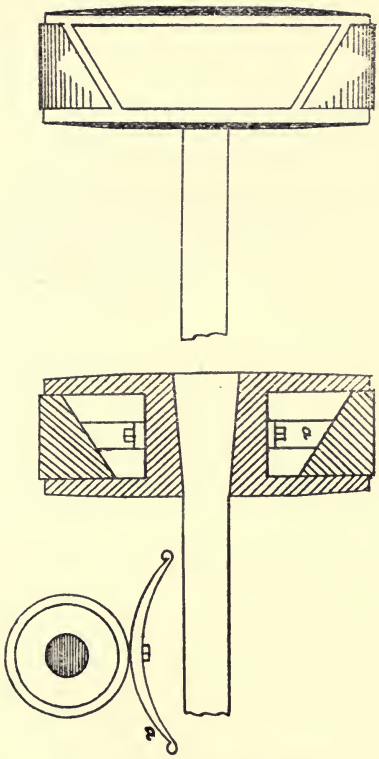


FIG. 13.—Built-up Piston Packing first introduced on the Monkland and Kirkintilloch Railway.

This Patent Specification alone shows that Dodds had as clear a vision of the locomotive engine and railway appliances as any engineer of the day; his provision for a new arrangement of cylinders alone showed that he fully realised the probabilities of extraordinary development in the future.

He was associated with William Owen, who was then a partner in the firm of Sandford and Owen, Ironfounders, of Rotherham, in several subsequent inventions for the improvement of machinery and in methods of manufacture.

Owen, whose works should take their place in railway history, was the son of a maltster. He was born in Rotherham in 1809, and obtained there his education and training as an engineer. In 1838 he joined the firm of Sandford and Yates, Ironfounders of that town, which was changed shortly afterwards to Sandford and Owen. Sandford then died, and Owen became sole proprietor, carrying on this important business until 1864; then Owen, who had been largely responsible for the invention of the solid weldless tyre, opened an establishment near the River Don canal at Rotherham for the manufacture of wheels, tyres, and axles, under the title of Owen's Patent Wheel Tyre and Axle Co., Ltd., and made a great reputation for the gigantic forgings produced there.

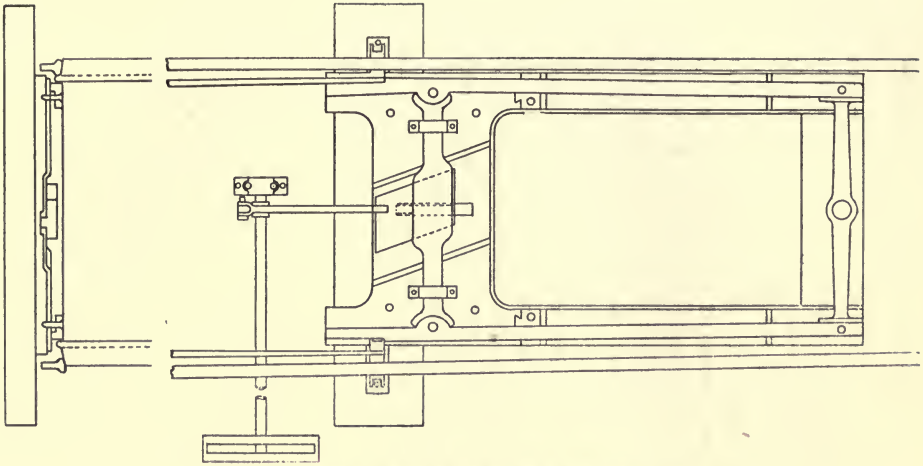


FIG. 14.—Self-acting Points and Crossings designed in 1839.

At the Great Exhibition of 1862 Owen exhibited a specimen tyre made by his solid weldless method and obtained much credit from engineers for the excellence and the manner of production. The first example of a solid weldless tyre known to have been produced was rolled by Messrs. G. and J. Brown (originally Knowles and Brown), owners of the Rotherham Forge and Rolling Mills, in 1859, by patent machinery specially laid down. Owen died in 1881 at the age of seventy-two years. He was a prolific inventor, and spent large sums of money in patenting his inventions, and although the majority of these proved, from a commercial point of view, fruitless, yet his efforts, numerous as they were, to effect improvements in the construction of wheels for railway purposes assisted in the production of the forged railway wheel which we have the benefit of at the present time.

CHAPTER VI

THE SHEFFIELD MECHANICS EXHIBITION OF 1840

THE position of the city of Sheffield as the centre of a huge coal and iron field was in the early forties one of great importance, its future was very optimistically spoken of in the industrial world, and the announcement of an exhibition of local manufactures and art productions caused great satisfaction locally and considerable interest elsewhere. Isaac Dodds promised the committee that he would send models of his inventions and other specimens of his work, as he had up to that time done little to popularise his efforts at the Holmes Engine Works. At the exhibition he displayed two drawings, one of a steam-engine fitted with the wedge eccentric motion, and another of his patent multi-cylinder locomotive engine. Furthermore, in order to show the wide and almost unlimited extent of his inventive genius, he exhibited a window blind cord stretcher, his patent wire cordage, an improved steam gauge, a model of

Dodds' and Owen's railway wheel, a model of the weighing machine which he designed in 1832, for the Newcastle-on-Tyne competition, a model of his parallel motion as described in 'Mechanics for Practical Men' by Professor James Hann, a full-sized gunstock being the first cut out by Dodds' patent curvi-linear sawing machine, and, lastly, his fowling-piece as patented in 1835.

These exhibits were the subject of great admiration on the part of all visitors, and Isaac Dodds received much credit and appreciation both for the trouble he had taken to show the public the results of his genius and for his capacity as an inventor. He also had the happy experience of accepting congratulations from three men whose names have been household words in the literary world, who were at that time and had been for very many years citizens of Sheffield. They were James Montgomery, Ebenezer Elliot, and Samuel Bailey, who, although dwelling in a busy smoke-palled town, lived far above their environs, and gave us some of the most beautiful poetry ever written in the English language.

A Quiet Period

From 1840 to the end of 1844 Isaac Dodds carried on his business at the Holmes Works with considerable success. He built many locomotives

and much of the rolling stock required for the Sheffield and Rotherham Railway and for the North Midland line. At the same time he occupied the post of Locomotive Superintendent and Resident Engineer, to which he had been first appointed in 1838.

He spent much time and money on the perfection of sugar-making plant, and his researches proved highly successful, for he obtained many orders from abroad for his vacuo-sugar boiling and refining apparatus. He carried out numerous experiments with wrought-iron girders, and was one of the first engineers to advocate the adoption of wrought iron in bridge construction. He commenced a series of tests in connection with the manufacture of steel with a view to its application to parts of locomotive engines subjected to abnormal wear and tear and to railway points and crossings.

In 1844 the Sheffield and Rotherham Railway ceased, towards the latter part of the year, to be worked as a separate line, for 'at a numerous and most highly respectable meeting' of the shareholders it was decided to accept the proposals of the North Midland Railway Co. for amalgamation, and after the tenth of October in that year the line was to become the property of the Midland Company. The services of the

officials thus became disposable, and as all the higher positions were filled Isaac Dodds did not offer to take further employment under the new organization, so that he was free to follow his own desires.

For eight years he had concentrated his inventive faculties on creating and developing numerous inventions. Among those which have not received mention are the compensating pendulum for clocks, invented in 1839; the modern type of undershot waterwheel; and his improvements in the supply of gas for illuminating purposes. In this latter he introduced the pressure equalizing valve worked on the principle of two cones forming a valve, the inner cone being varied in its opening action by means of a sensitive diaphragm, moved by the varying pressure of gas, adjusting the opening of the cone or valve to that position which would control the quantity of gas passing to the burner, and thus attain the automatic variation required for an equalizing valve.

At this period the WEDGE ECCENTRIC MOTION had become very popular among engineers owing to its extreme simplicity, and many tributes were received by Dodds to its efficiency. Thomas Kirtley, of the North Midland Railway, wrote from Derby expressing his opinion as follows:—

NORTH MIDLAND RAILWAY.

Locomotive Department,

Derby,

April 4th, 1844.

My Dear Sir,—

Yours of the 1st inst. is duly at hand, and can assure you that you have with all willingness my opinion and testimony respecting your Patented Eccentric Motion. Your motion was put upon three of the last Coupled Engines this Company had made: one by Messrs. Stephenson and Co., of Newcastle, and two by Messrs. Kitson and Co., of Leeds. The Engines have been at work regularly since the latter end of the year, 1842; the trifling repairs required to the machinery have been exceedingly little, and what has been required I consider is owing to the position of the Pumps. The saving of fuel by these Engines is very considerable, although it is but fair to state the motions are put upon Messrs. Stephenson and Co.'s Long Engines. The motion lately supplied by you, which I intend to put on one of our ordinary Engines, is not yet fixed, so that I am not able to speak to the saving effected over the common motion. My opinion is that when tried the result will be very favourable. To apply your motion direct, as in our case, the only machinery or joints required, beyond the Eccentric, are two Eccentric rods connected to the valve spindles in a direct line; in fact, in point of simplicity it exceeds anything that I have yet seen.

I am, dear Sir,

Yours most truly,

(Signed) THOS KIRTLEY.

MR. ISAAC DODDS.

In 1845 he accepted an offer from his brother-in-law, John Stephenson, to assist the latter's firm in the construction of the Caledonian and the Lancaster and Carlisle Railways, with residence at Glasgow. This he did with some demur, as he had intended extending the Holmes Engine Works and developing the business there for the benefit of his sons, the eldest of whom had just completed his pupilage as a civil engineer under Sir James Falshaw, Bart., who was at that time engaged in constructing various lines in the Midlands. However, circumstances did not allow the refusal of so good an offer, therefore he closed the Holmes Works and moved to Glasgow in the early part of 1845.

With Stephenson, Mackenzie and Brassey at Glasgow

One of the largest series of contracts undertaken by this eminent firm of contractors was for the construction of the Lancaster and Carlisle Railway, the Caledonian, the Scottish Midland and Central lines, which were main trunk lines, and a large number of branch railways in connection therewith. In 1845 they had in course of construction over 400 miles of railway, practically all in Scotland and the north of England, the engineers being in nearly every instance Locke

and Errington; Joseph Locke took up his residence at Moffat, near the Beattock Summit, and there watched the progress of work on the Caledonian line and elsewhere over the Border. John Errington took a similar responsibility south of the Border on the Lancaster and Carlisle Railway and also for the Kendal and Windermere. These works were sub-divided by the contractors and allotted to various agents, who were men of the highest attainments and integrity. At this time there were some fifteen engineers so employed; they included well-known names like Falshaw, who subsequently reached the highest position in his profession; Messrs. Woodhouse, Mould, Ogilvie, Meakin, and others whose names are inseparable from early railway history. The energy and determination in face of insuperable difficulties displayed by these old-time railwaymen makes one of the brightest and most inspiring pages in the story of British enterprise and industry.

The traveller who passes through the wilds of the north on his way to the great industrial area of the Clyde cannot fail to be moved by the wonderful and gigantic task of moving hills and piercing mountains which was successfully undertaken by our forefathers in an age which did not have the advantages of our modern machinery,

but had to trust to the pick and shovel, the hand barrow, and the horse-drawn wagon, no steam shovel lifting seven cubic yards at a single scoop, or compressed air drill which penetrates the hardest rock without the slightest protest. Dangers and difficulties had to be faced in those days by a stout heart, unsparing muscle, and risk of life. To-day such obstacles are overcome by some huge mechanical appliance obedient to every wish of its controller.

With the advent of the mechanical age it is not to be wondered that the spirit of romance has largely passed away with the old era, for present-day works do not call for those great qualities of character as formerly, the machine has relieved the human element of much of that responsibility.

Great praise is due to the navvies who worked on these lines, for never had they been called upon to demonstrate to such a degree their sterling qualities; these men, chiefly from the hills of Lancashire and Yorkshire, or from the fenlands of Lincolnshire and Cambridgeshire, were distinguished from all other workers by their extraordinary physical hardihood, their perseverance in face of danger and difficulty, and particularly their gift for improvisation.

With so large a number of men concentrated in different areas, it was not surprising to find

that outbreaks of rioting occurred sometimes, but on the whole their conduct was very satisfactory, the worst offenders being the navvies employed on the Lancaster and Carlisle Railway, for often on pay-days it was found necessary to keep in readiness a regiment of infantry and a troop of cavalry to keep the peace and put an end to rioting, with all its grave consequences. Very little was done to provide them with proper living accommodation, it being usual for every man to build a shelter for himself, the materials available consisting of turf, brushwood, and stone. In these hovels the workmen had to exist until the line was completed, a strange contrast to the excellent camping arrangements of the present-day public works contracts.

The construction of these lines involved many difficult engineering problems, both for the contractors and the engineers, the former having many miles of hard rock to cut through, and, in one case on the Caledonian Railway to the north of Glasgow, a tunnel had to be driven under the Monkland Canal and *over* the Edinburgh and Glasgow Railway, all within a few feet of one another.

It was further found necessary to reduce the amount of manual labour, and to this end every encouragement was given to inventors to submit

any labour-saving devices. It was on the Edinburgh and Glasgow line that the movable derrick-crane first made its appearance, for, although invented some little time before, its qualities had not been recognized. The inventor, William Wightman, after delivering a 'paper' on its advantages before the Society of Arts, submitted it to the examination of Messrs. Stephenson, Mackenzie and Brassey, who adopted it at once. Most of the viaducts and bridges on this line were erected by its means, and, as it originated in Scotland, it is known in the trade as the 'Scotch Derrick-Crane.'

Among many problems which the engineers had to face was the provision of an economical design for the short high level bridges and culverts which inevitably occur on an undulating railway. The construction of an arch was a very costly item, and in the event of uneven settlement, or in fact very little movement, serious damage would result to the arch.

Cast iron was the only other material in vogue, but could only be placed so as to resist compressive strains, and therefore did not assist matters to much extent. However, this trouble was subsequently overcome as the result of the successful solution of another question. A small stream, the Evan Water, had to be carried over

[*From an old print*

WOODHOUSE TOWER AND CUTTING ON THE CALEDONIAN RAILWAY

RAILWAY CONSTRUCTION IN THE 'FORTIES'

A typical scene of the excavation of a cutting called 'Making the Running.'

a deep cutting near the Beattock Summit on the Caledonian Railway, a road had also to be provided for the use of the farmer occupying the land which had been isolated from the main road by the cutting; Messrs. Locke and Errington, the Engineers, proposed to carry this stream in a strong wood trough, the span being about 90 feet, but the great trouble and expense of this design so impressed Isaac Dodds when making arrangements for its construction that he determined to lay other proposals before Thomas Brassey, who was then in Glasgow. After much thought, Dodds succeeded in providing a design which he thought would be a better substitute. This bridge, he suggested, should be formed like a trough and made of malleable iron plates spanning the full width of the cutting, the stream running inside the trough, which was of rectangular section. The roadway was to be carried on the top of the structure on a level with the approach roads from either bank of the cutting.

This design Dodds placed before John Stephenson and Thomas Brassey, and, in advocating the type of bridge, told of his experiments at the Holmes Works and the remarkable degree of success attending them. Brassey was so impressed with his proposals that he agreed to take full responsibility; Joseph Locke raised no objection

to the execution of the design, but when submitted to the Government Inspector it was at once vetoed owing to the lack of data concerning the behaviour of malleable iron girders under load. Eventually permission was given for the bridge to be built on the understanding that Thomas Brassey was to take full responsibility in the event of subsequent failure.

The bridge* was erected some time afterwards, the claims of its designer being fully upheld, and permission was given for several wrought-iron bridges to be built on the same principle for the Scottish Midland and Central Railways, thus dispensing with the costly masonry arching of the short-spanned bridges.

* Considerable interest is attached to this bridge, although it is not of large size. On the authority of the late Mr. Charles Manby, when Secretary of the Institution of Civil Engineers, it was erected in 1846. The writer, however, is unable to obtain complete confirmation from other sources. Mr. W. A. Paterson, the Caledonian Railway's present Chief Engineer, has kindly searched his records, but is unable to furnish any definite statement either to the contrary or in support of this. Further, Mr. A. Gourley, of Langside, Glasgow, formerly of the same Department, which he joined in 1860, has kindly given his views on the subject, but is unable to throw more light on it. To the best of his recollection a wooden bridge was at first erected and the iron bridge in question substituted some time later. Of this he is not, however, certain. In the Index Book of plans prepared by the Engineers, the first drawing is of a timber bridge or trough for carrying the Evan Water, and the next entry is the design of an iron bridge with the words ' not adopted ' written across. Unfortunately the drawings cannot be traced in the Plan Room, although mentioned in the Index Book, otherwise the explanation might have been found.

According to J. Guest, F.S.A., in his ' Relics and Records,' a local ' paper ' read in 1866, this bridge was erected as stated here.

Photograph by] [*T. Hood, Moffat*

MALLEABLE IRON BRIDGE AT THE BEATTOCK SUMMIT

Carrying the Evan Water over the Caledonian Railway.

(*See also illustration facing page* 91.)

It was about this time that Robert Stephenson took in hand the problem of spanning the Conway and Menai Straits, and in designing the bridges he was compelled to depart from the general practice of crossing wide gaps. While so engaged he happened to meet Isaac Dodds, his former companion pupil at the Forth Street Works, who had on many occasions freely given valuable assistance to him; he explained the difficulties of the situation, pointing out the many restrictions imposed by the Navigation Authorities and the unique nature of the site. Dodds at once gave the results of his experiments on wrought-iron plate girders of rectangular-box section, and strongly advocated the employment of this type of bridge in the experiments Stephenson proposed to carry out.

The original scheme projected by Robert Stephenson was for crossing the Straits by means of a wooden bridge which would only allow parts of the train to be taken over at the same time. This meant that a train would occupy nearly one hour before it could resume its journey on the other side. This fact, together with the question of clearances stipulated by the Navigation Authorities as being necessary before their sanction would be given, caused Stephenson to seek other methods of bridging with long spans. Cast-iron arches

were objected to by the Admiralty on the same grounds as the wooden bridge, because of the scaffolding required during the construction; these difficulties nearly causing the abandonment of the line, for it was only after numerous consultations with contemporary engineers that Stephenson decided to continue experimenting in other directions. He had received in the latter part of 1845 a certain amount of data concerning the behaviour of wrought-iron beams under various loads, but was not even then convinced of the ultimate safety of this material.

In 1846 Stephenson arranged for William Fairburn and Eaton Hodgkinson to undertake a new series of tests with a view to determining the correct form of wrought-iron beam for supporting an isolated roadway of great length. The first of these experiments was made with circular tubes, the second with elliptical, and the last with the form advocated by Isaac Dodds. Until the conclusion of the trials, some considerable time afterwards, Robert Stephenson held the opinion that a compromise between a suspension bridge and an iron-plate bridge might be made, in this way producing a stiffened suspension bridge.

By 1847, however, Fairburn and Hodgkinson had produced satisfactory formulæ for the design

Photograph by] [*T. Hood, Moffat*

VIEW OF THE BRIDGE AT BEATTOCK SUMMIT FROM THE WESTERN SIDE

Showing the stream passing through the bridge underneath the roadway.

(*See also illustration facing page* 89.)

of beams of large and small spans and of a variety of sectional forms. The result was that the science of bridge-building underwent a complete revolution in its laws, and the great Tubular Bridges connecting the Chester and Holyhead Railway and later the Menai Straits were built and used with absolute confidence.

Isaac Dodds had made a similar series of experiments with wrought-iron beams just after the opening of the Sheffield and Rotherham Railway in 1838. He was undoubtedly influenced to a great extent by his knowledge of Tom Paine's experiments, as there is every proof that Paine, during his employment with the Walkers at Rotherham, executed elaborate models and drawings of wrought or malleable-iron bridges.

The original ink drawing of the first wrought-iron bridge ever made came into Dodds' possession many years before Stephenson's tests were carried out. This drawing was subsequently given by him to the Patents Museum at South Kensington, through the medium of Professor Bennet Woodcroft. It was originally numbered 54 in the collection of drawings, and is supposed to have been executed by Paine in the year 1800.

CHAPTER VII

JOHN STEPHENSON

A FEW months after the opening of the railway from Edinburgh to Glasgow, Isaac Dodds had the misfortune to lose his brother-in-law, John Stephenson, who, together with William Mackenzie and Thomas Brassey, had taken many contracts for the construction of numerous lines projected at that time throughout Scotland. John Stephenson's death took place while on a visit to the North Midland Railway at Rotherham on July 8th, 1848, in connection with the maintenance contract following the completion of that line. The burial took place at the General Cemetery, Rotherham. He was a quiet and unassuming man, and like his brother-in-law, shrank away from thoughts or mention of publicity. Until the time of his death he was the principal railway contractor in the country, having been engaged on the construction of the first passenger railway under George Stephenson. His obituary notice gives only a small idea of the extent of his activities. It read

By kind permission of [*Miss F. A. Chalmer*

JOHN STEPHENSON

The principal Railway Contractor in this country between 1825 and 1848.

as follows: 'The death took place at Rotherham, suddenly, of John Stephenson, Esq., Murray House, Edinburgh, aged 54 years, the eminent and oldest railway contractor of that extensively engaged firm of Stephenson, Mackenzie and Brassey. He commenced his career under that most illustrious railway engineer George Stephenson, having been engaged in making the first passenger railway in this country. He was the contractor for the greater part of the North Midland Railway and many other lines. He was a man of sound judgment, unassuming manners, extraordinary and vigorous perseverance, and always inculcated, as far as possible, high moral and religious sentiments not only in private, but among his workmen. Few men have lived and died more respected.'

The work of John Stephenson as a pioneer railway contractor has never received that recognition accorded to many others. It has been often said that Thomas Brassey was the first of this order, but Brassey did not obtain his first contract until 1834; on the other hand, Stephenson had commenced his on the Stockton and Darlington Railway as early as 1824, and had throughout his career, until joining Brassey on the Scottish Line and the Lancaster and Carlisle Railway, been continuously engaged on contracts for

railway construction. He was much older than other engineers or contractors of the early nineteenth-century period, and while Robert Stephenson, Joseph Locke, Frederick Swanwick, John Errington, and other contemporary engineers were just beginning their training in railway work, John Stephenson was already an experienced contractor. He was largely responsible for the introduction of scientific methods into earthwork construction and the excavation of deep cuttings. George Stephenson relied to a great extent on the advice of John Stephenson for many of his early efforts at railway building, just as he entrusted Isaac Dodds for many of the technical details in the first engines of the Stockton and Darlington Railway; and it is but just and fair that the name of John Stephenson should be recorded along with those whose duties brought them more into prominence before the public and were consequently better known.

For his great work in originating new and efficient methods for the execution of enormous earthworks and the thoroughness of his system in organizing colossal numbers of unskilled workmen for the rapid construction of railways, and as a pioneer of one of the noblest of British industries, John Stephenson will ever have his name connected with the most eminent of his contemporaries.

JOHN STEPHENSON'S GRAVE IN THE GENERAL CEMETERY, ROTHERHAM

After the death of his brother-in-law, Isaac Dodds remained at Glasgow for two years and assisted in settling the obligations to the partners, Messrs. William Mackenzie and Thomas Brassey. His eldest son, Thomas Weatherburn Dodds, had at an early age been sent as a pupil to James Falshaw (afterwards Sir James Falshaw), who was then engaged on various railway contracts in the Midlands, and in 1845 had accompanied that celebrated engineer to Scotland, for the latter had undertaken an agency for the Contractors, Messrs. Stephenson, Mackenzie and Brassey.

In 1847 he completed his pupilage and went to Glasgow, where he joined his father, who was extensively engaged in his duties as consulting and technical engineer to the contractors. Here he had the good fortune to come under the influence of Joseph Locke, J. E. Errington, and some of the most valiant of old railwaymen like T. Woodhouse, G. Mould, Alfred Jee, who took great interest in his training, and whose influence in later years proved of great value to him.

End of the British Railway Boom, 1830–1850

With the approach of 1850 the intensive development of British railways subsided into the construction of minor works, the main trunk lines having for the most part been completed.

Both engineers and contractors therefore began to seek for new fields of labour. Thomas Brassey took contracts for various railways under the Italian and Norwegian Governments, Joseph Locke went to Spain, and other well-known men who had given their lives to railway work were scattered over every civilized part of the globe.

Isaac Dodds, together with Messrs. Jee and Mould, took the contract for the construction of a Spanish railway from the port of Santander to the Castile Canal at Alar Del Rey. They also undertook to supply the necessary rolling stock.

In order to take full advantage of the commercial openings which were offered in Spain it was agreed that Isaac Dodds should re-open his works at Rotherham and there construct the engines and rolling-stock required.

Accordingly on the completion of the new lines in Scotland, in the latter part of 1850, Dodds with his son removed to the scene of his former labours at Rotherham, and at once began the rebuilding of the Holmes Engine Works.

New workshops and furnaces were quickly erected, and a staff of highly skilled workmen carefully chosen. All efforts were concentrated on the manufacture of new machinery for the rapid output of railway engines and appliances, great ingenuity was exercised by father and son

THE HOLMES ENGINE AND RAILWAY WORKS, ROTHERHAM

The historic site of Messrs. Dodds and Son's Works. Here, in 1815–1819, was cast the old Southwark Bridge which formerly spanned the River Thames.

in the design of their machinery, and foremost among many inventions may be mentioned the modern plate-bending mill consisting of three large rollers with reversing gear, of the power driven type, for bending large boiler and other plates.

In this year Dodds and Son, as the firm was called on being re-established, took up the question of applying steel for railway purposes. Isaac Dodds had conducted numerous experiments on this subject during the early 'forties,' and the results fully bore out his contention that the application of steel to rails, tyres, and other working parts would reduce the wear and greatly extend the life of the material. These conclusions he transmitted to Sidney Jessop, of the well-known Steel Works at Brightside, near Sheffield, whose knowledge of steel manufacturing processes had made for him a wide reputation; together the three engineers investigated the problem, and after some months of experimenting, Jessop succeeded in working out a process of welding a bar of steel on the ordinary wearing surface of either tyre or rail bar, by a relatively inexpensive system of continuous welding during the passage of the iron bar through the rail-mill.

About this time the Great Exhibition to be held in the summer of 1851 at the Crystal Palace,

London, attracted the attention of all those engaged in the industrial world. Messrs. Dodds, however, had little or no time to prepare any elaborate specimens of their productions, and contented themselves by sending five examples of their manufactures. These were :—

1st. A full-size 4-horse power portable steam-engine having direct motion given to the slide-valve by a return crank.

2nd. A model locomotive engine without its boiler, fitted with their patent expansive ' Wedge-Motion.'

3rd. A piece of Jessop's patent steeled tyre bar, for railway wheels.

The wearing surfaces of the tyre were converted into steel (either in the bar or after being welded into a hoop), but only so far as was necessary to maintain the working surface, by which all the toughness and ductility of the iron were retained, while the steel parts could be hardened or ground up.

4th. A piece of rail bar, with the wearing surfaces steeled by Jessop's process, the rail being of greater strength and durability ; it did not laminate or splinter, and gave a uniform hard wearing surface. The strength of wrought iron, it was believed, was considerably increased, consequently allowing rails to be made much lighter.

5th. A model of the rail straightening press, as invented in 1838, mounted on a railway truck, avoided or dispensed with the use of a hammer, straightening much quicker and without damage to the rail. . . . The portable engine described in the first item of this list was made after the same design as the modern portable engine now in use, its prototype, constructed twelve years previously for employment in agriculture, was undoubtedly the first portable engine to be invented and applied to everyday uses. A very fine engine of this type was built by Messrs. Dodds for Messrs. Kirk and Kidgell of the Buttermarket, Foundry, Rotherham, and was delivered to them prior to 1845, before the inventor left that town for Glasgow. Large numbers of these engines were built at the Holmes Engine Works subsequent to 1851, and sent to India, Spain, Portugal and America.

The third item is referred to later in the improvements to steel manufacture, Sidney Jessop's invention then being described; and the fifth item was the rail-strengthening press mounted on a truck, an invention first brought into use on the Sheffield and Rotherham Railway in 1838, and registered by Dodds as an 'Article of Utility' in 1848. This press was the original of that ingenious device for bending rails, popu-

larly called the 'Jim Crow' by all platelayers (Fig. 15).

For some years after the Great Exhibition Dodds and his son were busily engaged in the manufacture of locomotives and rolling stock, and

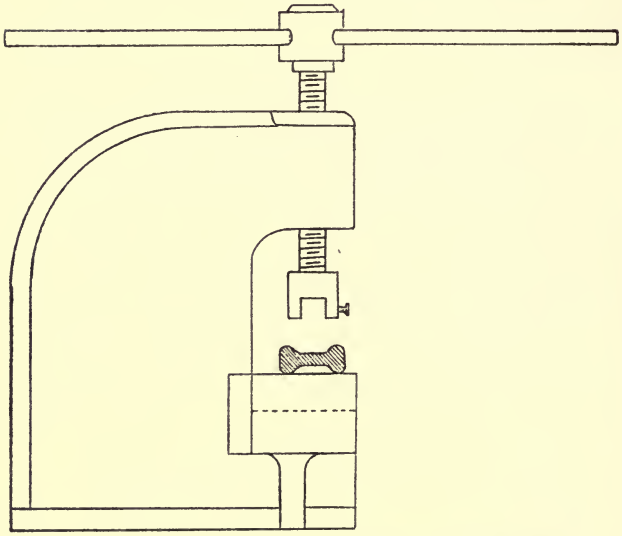


FIG. 15.—The Rail Straightening Press, cast in one piece, as employed by Dodds on the Scottish lines, 1845–1850, but originally used on the Sheffield and Rotherham Railway in 1838, when it was of the built-up pattern, made in wrought iron.

gained a wide reputation for originality of design and excellence of work.

In the early ' forties ' Isaac Dodds had produced an exceedingly neat and serviceable spring clip for fastening or strapping gentlemen's nether garments to their boots; and, as this became universally popular because of the fashion of the day, thousands of these clips or attachments were made at the Holmes Engine Works and exported all over the world of Western civilization.

The numerous patents and inventions brought out by the senior partner produced a large revenue, one of the most profitable being the ' Wedge Expansive Motion,' which had by then been fitted to many steamship engines, colliery winding engines and locomotives. This motion also found great favour with Isambard Kingdom Brunel for his engines of the Vale of Neath Railway and other locomotives of the Great Western line.

CHAPTER VIII

A PAGE IN THE HISTORY OF IRON AND STEEL

NOTWITHSTANDING a lucrative business, however, both father and son continued their costly experiments with various mechanical devices. In 1852 they determined to investigate and conduct exhaustive researches once more into the question of steel manufacture, as they were convinced that the lack of wearing qualities in wrought iron was retarding the progress of engineering. Thomas Dodds was given the task of completing the attempts begun by his father in previous years. Hundreds of pounds were spent on new furnaces, which were repeatedly pulled down and rebuilt afresh ; large quantities of metal, crucibles, alloys and fuels were used in the endeavour to achieve the desired object, but it was not until Christmas of this year (1852) that a satisfactory measure of success was achieved ; it was the subject of a patent applied for on 7th March, 1853, and sealed 1st September, 1853.

In this patent Thomas Dodds was granted nine

claims for his inventions, and of these four are of particular interest :—

1. The conversion of iron into steel wholly or partially by the use of a carbonaceous fuel, or a mixture of soda-ash, lime and charcoal, or any mixture of alkaline matter, with carbonate or bi-carbonate of lime, or matter containing lime with charcoal.

2. The conversion of iron into steel by use of a compound of these substances.

3. The mode of treating iron, partially or wholly converted metal, by plunging the same when red hot into a wet or dry bath, either into water, water impregnated with carbonaceous matter, or liquid ammonia, etc., or a solution of potash ; also into a mass of dry carbonaceous material like sand, charcoal, and soda-ash or other carbonaceous matter.

4. The system of arranging and working the furnaces of conversion, wherein the retorts or converting chambers may be charged and discharged while they are in a working condition, without being permitted to cool (Figs. 16 and 17).

In a paper given to the Institute of Mechanical Engineers on June 25, 1857, at Manchester, Thomas Weatherburn Dodds described the process in detail. The following extracts taken from his description will serve to demonstrate the

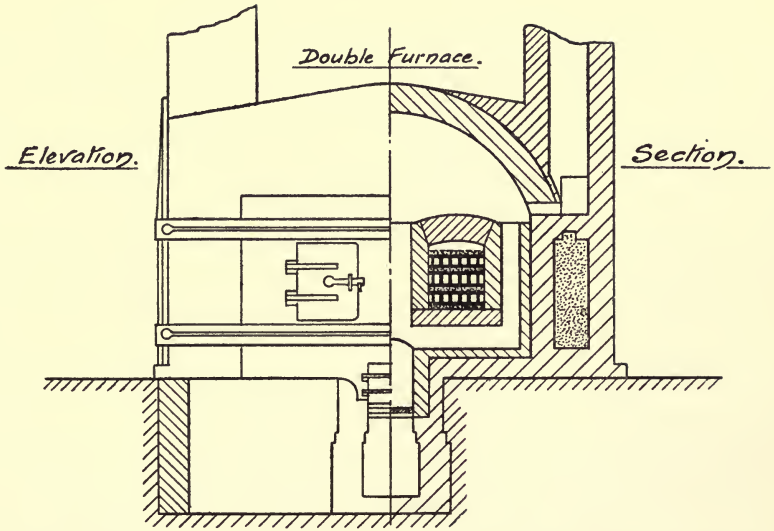


FIG. 16.—Transverse views of Dodds' Cementation Steel Furnace as developed in 1856 and erected in the U.S.A. for Carnegie in the early sixties. Section shows method of inserting the rails.

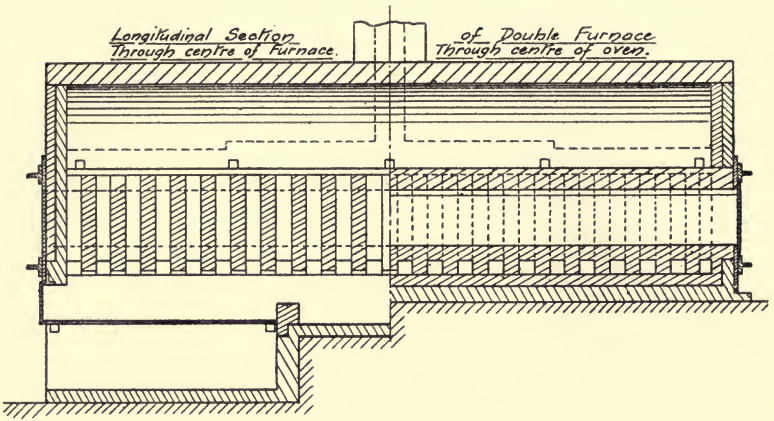


FIG. 17.—Longitudinal Section of Rail Conversion Furnace.

great importance this discovery takes in the history of iron and steel manufacture :—

'The author of this paper, following out a series of experiments that were for several years carried on by his father, devised a converting steel furnace that admitted of being charged and drawn without interfering with the heat or combustion.

'The commercial advantages obtained were—economy in coal 50% and a much greater economy in time without detracting in any way from the quality.

'It has been a point often aimed at in the manufacture of iron to increase the hardness and durability of the working surface. The best recognized up to the present are the chilled railway contractor's wagon wheels; case-hardening and the welding of a bar of steel on the wearing surface of tyres, and other experiments made by Mr. Sidney Jessop, who spent much time and money in this and who produced the further advance of submitting portions of the iron where hardness was essential to the continued action of carbonising fuel, thus producing a steel furnace. This effort of Mr. Jessop led to the series of experiments on which is based the process described in this paper, the results of which were pure blister steel.'

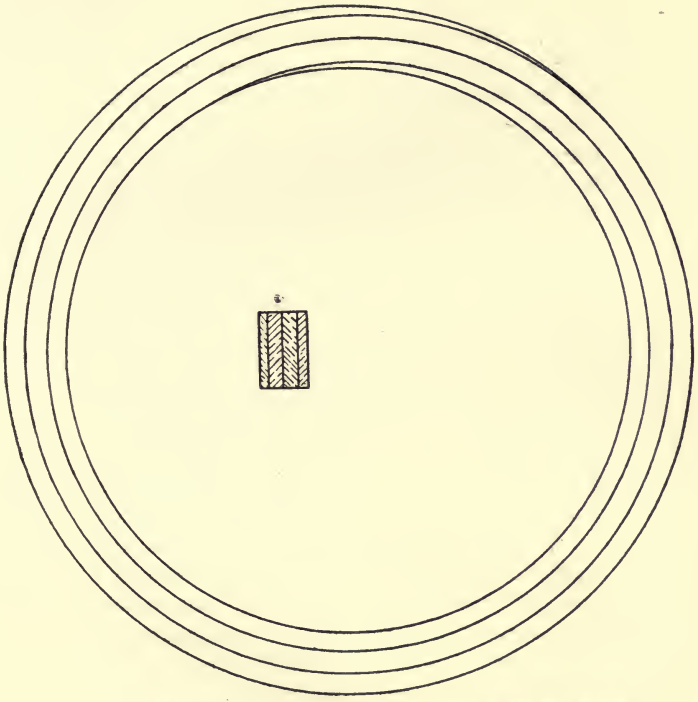


FIG. 18.—Method employed at the Holmes Engine Works for forming railway tyres. The volute coiling obviated the single lap weld of the ordinary type. 1854.

For many years the Messrs. Dodds had been strong advocates of steel rails, and in his paper T. W. Dodds took the opportunity of placing their views before a meeting containing many eminent railway engineers; he further pointed out that 'if the surfaces of the rails are protected from the wear of the wheels rolling over them by a coat of hardened steel 3/16th-inch thick, there can be little doubt that a rail thus encased in steel would last three times as long as the ordinary rail, it would still retain its tough core of wrought iron, and for all the purpose of a rail would be better than if formed of either material alone.'

In comparing costs of iron and steeled rails he stated that the life of an iron rail was not more than seven years, while the steeled rail could be taken at twenty-one years. Further, the iron rails steeled by this process cost only £1 per ton extra, which was insignificant when considered against the subsequent economy. He estimated that the adoption of steeled rails would result in the saving of £110 per mile per annum, 'a very important addition to the resources of any railway.' He proposed to apply this process to the hardening of wheel tyres, axle journals, piston and valve rods, and machine tools, also to an infinite number of other articles.

THOMAS WEATHERBURN DODDS

One of the most prolific inventors of the last century.

There was a very interesting discussion at the conclusion of this paper, Joseph Whitworth, John Ramsbottom, McConnell, and others taking part in it; after many questions had been asked and answered, it was admitted by all that the plan or process described was a distinct advance on any system then in use. Before the conclusion of the proceedings, Isaac Dodds remarked that he had seen rails steeled by this process after eighteen months' wear at the London Bridge Station, and that they showed no signs of wear. It was also said that twelve sets of steeled railway tyres were at work on the Caledonian Railway, and had been running there a long time with complete success, also some coupled tyres on the Midland Railway. Steeled files converted in this furnace had been in use at Newcastle in engine shops there and were fully approved.

The tremendous economy resulting from the adoption of hard surfaced rails, as obtained by this process, excited great interest in engineering circles, and some little time after the invention of 1852 steel points and crossings began to take the place of iron, and gradually the iron rail was replaced by the steeled type. Messrs. Dodds, however, never reaped the full reward they deserved, for, some time afterwards, the direct conversion of steel was brought out by Henry

Bessemer, and by the year 1865 the Bessemer process was generally adopted in this country, and the first charge of that metal had been 'blown' in the United States of America (at Troy on February 15, 1865).

Isaac Dodds had been the first engineer to advocate the wide use of steel in place of iron and had thereby given a strong incentive for others to experiment in that direction.

Writing in an Obituary Notice following the death of Isaac Dodds, the late Mr. Charles Manby (formerly Secretary of the Institute of Civil Engineers) said: 'It must be admitted that by the introduction of steeled rails by Messrs. Dodds, who had great prejudices to overcome but who persevered and spent freely to prove the economy, increased durability, and superior working of steel as against iron, they were the "pioneers" of the rails which railway companies have now almost universally adopted.'

The importance of employing steel for rails and tyres had been realized by Isaac Dodds while he was Engineer to the Sheffield and Rotherham Railway, and in his associations with local iron and steel manufacturers he often spoke to them on the necessity for a careful investigation of the question; in this he found an able supporter in Sidney Jessop and one who would give very

much practical aid in making experiments. A fitting tribute to that gentleman's efforts in this direction have been referred to in course of the extracts from the paper read by T. W. Dodds. Several patents were taken out by Jessop with a view to accomplishing this object between 1840 and 1850.

The story of the wide adoption of steel rails is a long and complex one. The first occasion which caused an earnest desire among engineers for further progress and knowledge of the subject was the Great Exhibition of 1851, when a few enterprising firms produced samples of iron bars provided with a veneer of steel welded to the surface during the process of rolling. Following this method came Dodds' invention, giving all the advantages which could be desired from an engineering and commercial point of view. Four years afterwards Henry Bessemer announced his discovery of a still cheaper process and Siemens subsequently brought the art of steel-making almost to perfection by his Open-Hearth system.

Iron rails, however, died a lingering death ; the old prejudice against the new order of things delayed their final supersession until the approach of the present century.

Locomotives for the Santander Railway

In the summer of 1852 instructions were received for the commencement of the order for the construction of rolling stock required on the Santander and Alar Railway in Spain. The locomotives and carriages were to be so designed as to be capable of easy transportation by road, and certain limits in size and weight were on no account to be exceeded.

The design was executed by T. W. Dodds with the advice and assistance of his father; apart from the restrictions of loading gauge and the problem of carriage from the Spanish seaport of Santander to the Railway Depot at Los Corralles, the designers had a 'free hand.' Within a short time they produced drawings of a series of six-wheeled, four-coupled, mixed traffic engines. The first of these splendid locomotives was named 'Ysabel' after the Spanish Queen Isabella II., and was fitted with many of Messrs. Dodds' patent devices for locomotive engines.

On their completion at the Holmes Engine Works, Isaac Dodds was very anxious to test one of them on the steepest portion of a British main line. Accordingly he wrote to his friend, Mr. Stalvies, then a Locomotive Superintendent of the Birmingham and Gloucester Railway, and

offered to send the engine 'Ysabel' to work for a short time on the 'Lickey Incline,' near Bromsgrove, so that comparative tests might take place between it and the engines then in use. This offer was accepted by Stalvies with alacrity, for he was well acquainted with the products of Isaac Dodds' genius, and knew full well that the results would justify any expense incurred.

Early in 1853 the locomotive 'Ysabel' left the Holmes Works and proceeded for her trials to Bromsgrove. On her arrival there she was taken over by Stalvies, then living at Bromsgrove; after a few preliminary trips she was taken into the sheds and prepared for her tests on the main line

On the occasion of the first trial the load was made up of trucks and coke wagons, six in all, and weighing nearly 46 tons exclusive of engine and tender. Starting with this load from Bromsgrove Station, at the foot of the incline, which was a gradient over 2 miles in length, and rose 1 foot in every 37; the 2 miles and 1 furlong were surmounted in 12 minutes, 12 seconds, the engine all the way accelerating from 42 to a maximum of 66 strokes per minute, no slipping was perceptible, although at the time it was raining and the weather conditions generally were decidedly against good running.

The next test up the incline was the heaviest passenger train usually at work on the line. It weighed nearly 30 tons, and was considered the maximum load permissible for one engine to haul up the severe climb.

With this train behind, the engine started as before from the bottom of the incline and ascended in 7 minutes and 5 seconds, or at the rate of 18 miles per hour. Throughout the trip speed accelerated and there was no slipping of any importance. The engine had four wheels coupled with a carrying wheel under the cylinders at the smoke-box end, they were 4 feet 6 inches diameter; the cylinders were 14½ inches diameter with a stroke of 20 inches. It was fitted with Isaac Dodds' patent wedge-motion, and was so constructed that the cylinders, with the whole machinery, were attached to the frame completely independent of the boiler. If necessary the boiler could be detached or removed in a few hours, the only joints having to be made being the steam pipes and feed-water connections. Thus the boiler was entirely free for expansion or contraction. Further advantages were that only two eccentrics moved the valves instead of the four required in the Stephenson-Howe link-motion.

In referring to these trials a correspondent of

the 'Practical Mechanics' Journal' (Volume VI, April, 1853—March, 1854) says: 'The engine is also entitled to great commendation from its great simplicity of arrangement and the means of disconnection for easy transport over a mountainous country, no part being more than six tons weight when detached. Such a test with an engine never intended running up inclines of this class with a load cannot but be regarded as eminently successful.'

The weight of this type of engine when in working order was slightly over 20 tons, the tender carrying 970 gallons of water and weighing six tons. The engine boiler was of the usual multi-tubular type, and was fitted with 137 copper tubes $1\frac{7}{8}$ inches diameter, 11 feet 3 inches long.

The satisfactory results achieved during the trials at Bromsgrove by this class of locomotive proved to its designers the soundness of their theories and the thoroughness of the workmanship displayed by the mechanics of the Holmes Works. When these engines arrived in Spain, notwithstanding the rough handling received both during the voyage by sea and the long journey over mountainous country from port to the Los Corralles engine depot, all the sections on being unpacked were found to fit with the most astound-

ing accuracy and precision. The engine erectors sent from the Holmes Works, on returning from Spain, were highly enthusiastic concerning the perfection of the various parts, also the ease with which they had been assembled; and gave a glowing account of the splendid performances of the engines when at work. Many compliments were received by Messrs. Dodds from the Spanish engineers who were engaged on the Alar and Santander Railway, and this reputation gained for them a flourishing trade with that country for nearly twenty years.

Coal-Burning Locomotives

At this period of locomotive history (1853) coke was the only fuel in general use, although wood was often used as an auxiliary fuel. It was not an unusual thing, even in the late 'sixties,' for an engine to run short of coke, and if that situation arose in some lonely part of the line the only remedy at hand was for the fireman and guard to arm themselves with axes and crowbars, leave the train and proceed in search of an efficient substitute. Their objective was, as a rule, the nearest convenient gate which they would rapidly reduce to matchwood, and after a few such journeys sufficient fuel would be obtained wherewith to get up steam and thus complete their

journey home. No wonder that railways were so unpopular among farmers of that day, for with the mysterious disappearance of their gates and fences, the fires in their cornfields caused by the sparks of red-hot coke and wood, and the general disturbance of peaceful neighbourhoods, they considered their lot a most unhappy one!

The necessity for the employment of coal in lieu of coke and wood had for long been the subject of controversy among locomotive designers, as it was almost impossible to increase boiler dimensions under existing conditions, the heat of a coke fire being so local in its action that most of the steam generation took place in the firebox and the force of a strong blast drew the particles of coke through the tubes and ejected them from the firebox without being properly burnt. The excessive cost of coke over coal and other objections also made it imperative to provide a substitute.

Messrs. Dodds fully recognized the demand for a coal-burning locomotive, and in the latter part of 1852 were engaged in conducting various experiments with a view to producing a firebox capable of allowing perfect combustion of coal and at the same time subject to easy regulation by the fireman.

The principle they subsequently determined

upon consisted of two combustion chambers placed tandem-wise under the boiler, in one case the firegrate near the door was composed of a set of water-tubes which were screwed into cast-iron headers, in almost the same manner as the modern superheater pipes. This grate was sloped upwards from the firebox door to the boiler barrel in order to promote circulation. In the forward chamber a coke fire was to be maintained, so that the green gases from the back chamber would pass through the water tube grate over the white-hot surface of the coke fire, and there be mixed with sufficient hot air to cause immediate and complete combustion. The supply of air was regulated to any desired quantity in both combustion chambers by means of carefully fitting dampers, and the firing door was specially designed to prevent cold air interfering with the combustion of the coal-fired furnace. Various baffle plates or walls of firebrick were employed to direct the air where satisfactory mixing of gases could take place.

The system will be better understood by reference to Fig. 19, which is a longitudinal section of a locomotive firebox; in this coal was burnt on the bottom grate and the unconsumed products of combustion were directed upwards by the baffle plate to the back of the firebox roof and

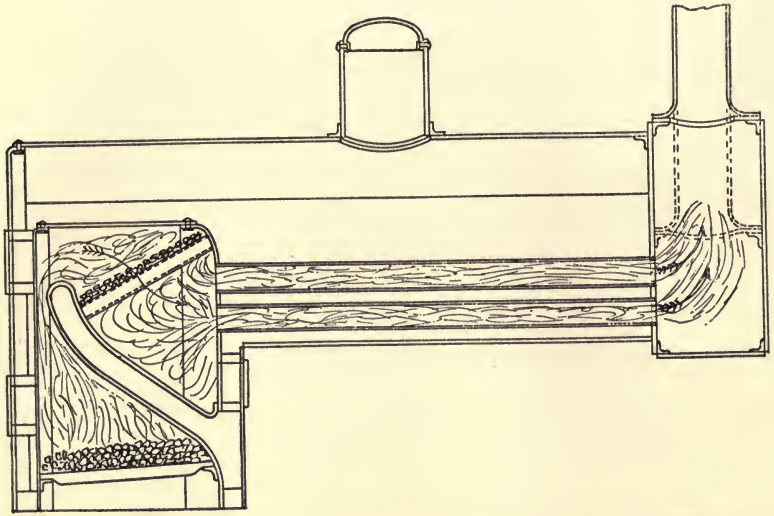


FIG. 19.—Coal-burning Locomotive Boiler built and invented by T. W. Dodds in 1853–1854. The fire-arch was made of copper plates and had a water space. The top grate consisted of inclined tubes fastened to the arch top and were employed to obtain circulation of the water. This was one of the first designs achieving any considerable measure of success in coal burning.

then were drawn towards the smoke-box by the blast, on their passage being ignited by contact with an incandescent plate of firebrick. When first lighting up the boiler, two fires were to be started, the top burning coke and the bottom coal. As the lower fire was built up and dense gases were generated the top fire would be at a temperature sufficient to ensure complete combustion of unburnt particles and gases drawn from the fire below. When once started, it was not found necessary to add fuel to the top fire, as this became a point where combustion took place and therefore was the hottest part of the firebox.

The importance of an even supply of air to allow perfect combustion was clearly provided for, arrangements being made for the admission of a current or currents of air in front of the bridge, the plate, and behind the brickwork of the bridge; also at the mouth of the firebox, over the top, and through the sides of the same.

Messrs. Dodds also adapted their design to stationary and marine boilers, and further introduced water-tube firegrates (Fig. 20) into the combustion chamber; these were in this case placed forward of the ordinary firegrate, so as to receive full benefit from the combustion of the gases near the incandescent firebrick plate. The

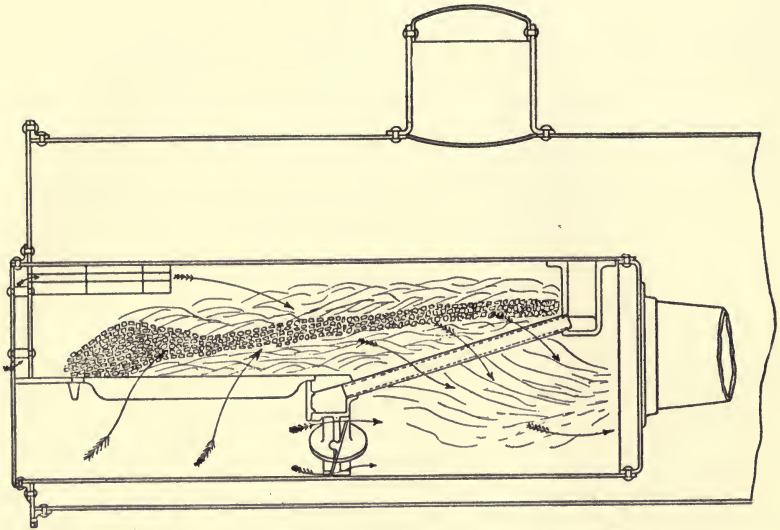


FIG. 20.—Marine type of Coal-burning Boiler with water tubes in the firebox. 1854.

tubes were inclined in order to promote circulation, and were connected to the boiler through cast-iron headers into which they were screwed both at the top and the bottom. The diagram in reference shows its application to the standard land and marine type boiler as manufactured during 1850–1870.

This arrangement proved eminently successful, Messrs. Dodds thus being among the first engineers to make a coal-burning locomotive capable of consuming its own smoke without introducing extraordinary complexities into their design. Many engineers in this country evolved modifications of the method subsequent to the publication of its particulars, and were thus able to reap advantages at Messrs. Dodds' expense. Many Continental locomotives were, however, built on this plan, and, together with other improvements brought out by them, made for their names amongst engineers of France, Spain, Germany, Italy, and other European nations a great and lasting respect. This improvement was the subject of a patent granted to Messrs. Dodds in October, 1854.

CHAPTER IX

THE SLIDE-MOTION

NUMEROUS inventors were at this period busy with new ideas and improvements on the subject of machinery for working steam valves, many of these being complications of existing designs and caused legitimate inventors a great deal of trouble. With a view to protecting the 'Wedge-Motion' from these trespassers, Isaac Dodds patented a modification of that device so protected in 1839. This he called the 'Slide-Motion,' because the eccentrics were adjusted to the different positions required by means of sliding bushes. It will be seen that the design, as demonstrated in Fig. 21, acts on the same principle as the 'Wedge-Motion,' the only feature differing from it being the means of moving the eccentrics, instead of vertical wedges, the bushes or slides, on which the eccentrics were mounted, had keys fastened to the top and bottom halves. Each key being at an angle to the centre of the axle, when the slides were moved the position of the

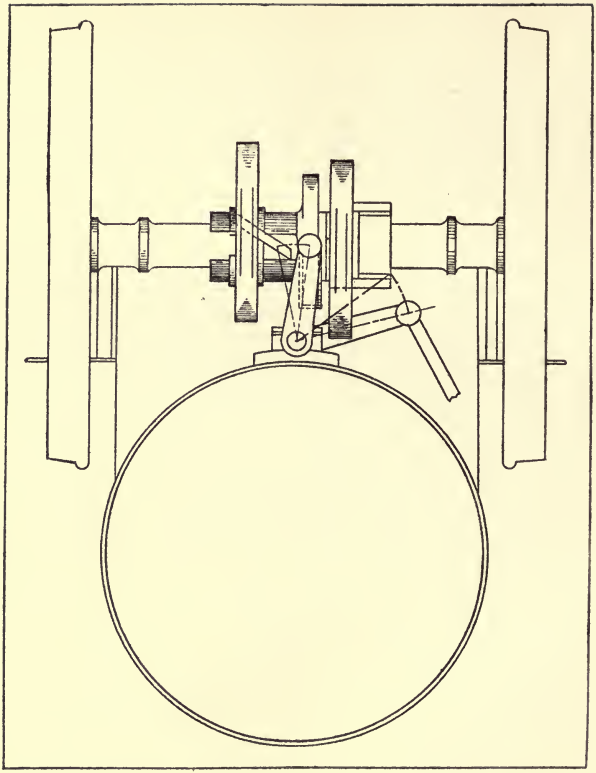


FIG. 21.—The Slide-motion. The eccentrics are moved across the axles by sliding bushes holding inclined keys.

eccentric was changed accordingly by a relative movement transversely across the axle.

This type of motion was never used to any great extent although its inventor succeeded in getting it tested on main-line locomotives; many engineers raised the same objections to it as they had done to the 'wedge' eccentric gear. They were apparently afraid of the square section at the centre of the crank axle, and also of throwing all the strain of keeping the position of the eccentric on to the wedges. However, from the evidence adduced it seems that with the light nature of the duties required of an eccentric on locomotives of those days, which were only half the power of their present descendants, no reasonable mechanical trouble could be found in its mode of construction. One reason for the subsequent lack of popularity of both gears may have been in the fact that in their case a royalty had to be paid, whereas in the instance of the link gear, which was never patented in its present form, no restrictions were placed on its use. Certainly no simpler contrivance for producing an apparatus capable of giving varying movements to a slide-valve has since been produced. In the matter of construction in the workshop it was a simple gear to make, no special machinery having to be employed for grinding the link or complex

arrangements of counter-weights and levers, the movements of the valve being direct to the eccentric.

Improvements to Ordnance, 1854

The outbreak of war against Russia in 1854 drew the attention of many engineers to the improvement of existing military weapons, and as the result a large number of new devices for destructive purposes were patented and the manufacture of munitions of war became the principal work of all engineering establishments in the country. In keeping with the situation, Messrs. Dodds were early in the field with a series of improvements to artillery for use in the trench warfare carried on so long in the Crimea.

Rifled cannon had not then appeared, and as the ordinary smooth bore cannon had reached the maximum possible size, other methods had to be found to enable heavier 'ball' being used. In their invention, patented in 1855, Messrs. Dodds proposed to employ a projectile with a hole or chamber in its base to fit the outside of the gun barrel instead of being placed inside according to the usual arrangements; by another modification a tail-piece was formed on the projectile, which tail fitted into the bore of the projector. while the main body or head of the

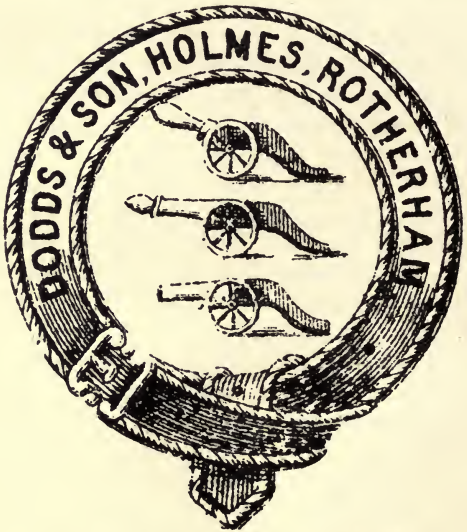
projectile containing the explosive charge could thus be made much larger than the bore of the projector. Many advantages were thus gained since a much larger projectile could be used with a projector of small weight and size.

This type of gun, although made and invented over half a century ago, was used during the recent European War in thousands by the British Armies. It was known and will be recognized by many readers as the 'Medium 2 Trench Howitzer,' firing a shell popularly termed the 'football.' Many of these guns were made at the Holmes Engine Works between 1854 and 1868 and exported to France and Germany, where they were highly approved.

Other innovations included the strengthening of cannon by the application of a cast-steel breech lining, and the adaptation of a separate trunnion mounting in place of the old and unsatisfactory method of making the trunnions in one piece with the main casting.

The satisfactory outcome of these experiments with ordnance was of such a nature that the designers registered a Trade Mark with the guns forming the centre piece, whilst their residence at the Holmes, which they built some distance from the Works about that time, was named 'Ordnance Villa.'

With the advent of peace and the restoration of confidence between the Great Powers, British engineering firms again turned their attention to progressive works, and Messrs. Dodds obtained large orders for engines of the locomotive, portable and colliery winding types, from Spain, Portugal, and India, and there seems little doubt that, had they wished, a vast connection could have been built up. They, however, preferred to continue



Trade Mark adopted by Messrs. Dodds in 1855.

THE STEAM YACHT *GAZELLE*

Designed and built at the Holmes Engine Works by T. W. Dodds, 1860, for the purpose of demonstrating the advantages of steeled plates in shipbuilding.

the policy of experimenting and devoting most of their time to various inventions, and in this respect turned their attention to a branch of engineering which was somewhat of a novelty for construction in railway shops.

The Steam Yacht 'Gazelle'

With the object of demonstrating the many purposes where their numerous inventions might with great advantage be put into practice, in 1857 Messrs. Dodds resolved to incorporate certain of their patents in the design of a large steam river yacht. It was proposed that on its completion at the Holmes Works, it should be sent to the Great Exhibition, then being arranged for opening in 1862; Thomas W. Dodds was allotted the task of the yacht's design, after his father had worked out the dimensions in general. She was to be 57 feet in length over perpendiculars, 7 feet beam, with a draught forward of 3 feet, and aft 4 feet and 3 inches; the keel was to be one solid forging from stem to stern, while the plates of 3/16th inch thick were to be steeled by their patent process.

The use of steel plates for shipbuilding had up to 1865 received little or no consideration from marine architects, and few instances are recorded where such an innovation was tried. Laird, at

his Birkenhead shipyard, built a steamer of 170 tons displacement, which was made of steel plates converted on Riepe's system. This boat was named the ' Rainbow,' and was intended for the Niger Expedition. She was tried on the River Mersey on July 3, 1858, and sent to Africa a fortnight later, and, owing to the lightness of her construction (made possible by the substitution of steel plates), was found to be of incalculable benefit in the navigation of the shallow rivers and lakes of Africa.

Previous to this Dr. Livingstone had taken out a small steam yacht to Africa on his explorations, the plates of this vessel being made of the steeled plates as produced by Messrs. Shortridge, Howell, and Jessop, of Sheffield. This, however, had not been a great success from a commercial point of view, the process being far too expensive.

The engines of the angular type of 16 horse-power, were specially designed to economise space, they had the patent ' wedge ' expansive motion, one eccentric working both valves direct without weighbars or rocking shafts, one lever starting, stopping, reversing or working the engines expansively, as required. The boiler was of the locomotive type, with a copper firebox and brass tubes, and had a working pressure of 200 lbs.

per square inch; the screw was of steel, 3 feet 10 inches diameter, with a pitch of 6 feet.

The cabin was made to accommodate thirteen persons and was sumptuously fitted with the finest upholsterings and decorations.

The members of the crew were supplied with uniforms of a nature appropriate to their calling, their caps bearing the name of their precious craft. When completed the 'Gazelle' made a very graceful and inspiring picture, and from 1860 to 1861 was frequently seen ploughing her way through the waters of the River Don.

After many successful tests she was sent to various exhibitions and demonstrated to marine architects the unlimited possibilities of steel as applied to shipbuilding.

Subsequently the 'Gazelle' was sold privately to a gentleman for use on his private lake, although her disposal involved Messrs. Dodds in considerable loss, they being poorer to the extent of £1,000.

The illustration of this small but beautiful craft gives further tribute to her designer, T. W. Dodds; the figure head, being the head and forepart of that most graceful of all animals, the gazelle, was cast in bronze and completed to perfection one of the most elegantly proportioned vessels of that type which has ever 'taken the water.'

The Construction of the Santander and Alar Railway in Spain

The work on this railway under Alfred Jee, as chief engineer, began in 1852, Messrs. Dodds undertaking to construct that part between Alar Del Rey and Los Corralles, a distance of thirty-five miles (Fig. 22). The section of twenty-six miles between Los Corralles and the port of Santander being undertaken by Isaac Dodds' former assistant on the Sheffield and Rotherham Railway, G. Mould, and his son, John Mould.

Many difficulties were met with in course of the work, labour problems being the most troublesome. The line running south from Santander passed through a mountainous district, and had to be carried around precipitous mountains, across deep gorges, and over torrential rivers, no more difficult work having presented itself to the railway builder at any time. Thomas Brassey had a similar experience when constructing the railway from Bilbao to Tudela (in 1858), and in no part of his wide experience as a contractor did he pass through so trying a period; it is said that he lost over £200,000 on the completion of the work.

The climate in that part of Spain being very wet prevented the execution of work for at least

several months in the year, while the number of 'fête-days' further interfered with operations, so that only seven months' work was done yearly; and had it not been that Messrs. Dodds recruited many skilled tradesmen and men highly trained in railway work from home, the process of con-

SPAIN

FIG. 22.—Map of the Santander Province showing the line constructed by Dodds and Mould from Alar to Santander. In passing the Cantabrian Mountains, between Pesquera and Barcena, a direct distance of only three miles, a detour of twelve and a half miles is necessary, and includes seven sharp curves, also eight tunnels.

struction would have been prolonged over many years.

Further, throughout the time that British railway engineers were occupied in that country, a kind of guerilla warfare was waged against brigands, who made the mountains their home. Principal among these were the Carlist supporters, who took every opportunity to delay the work of construction by threatening the lives of the Spanish labourers and often doing great damage to the works. Had it not been for the courage and determination of the British engineers and their men, whose actions gave confidence to the native employees, the opening of the lines might have been postponed until many months afterwards.

In the latter part of 1853 the first consignment of engines and rolling stock had arrived, also many parts for the bridges which had all been made at the Holmes Engine Works by Messrs. Dodds.

By March, 1857, however, the section of line from Los Corralles to the southern terminus with the Castile Canal at Alar Del Rey was completed and opened for traffic, a result highly creditable to Messrs. Dodds and Son, and the second part from Los Corralles to Santander was within some few months of completion. Notwithstanding the

enormity of the difficulties encountered, the end of their labours did not appear to be far away.

The following year, 1858, as the completion of this last section was drawing near, it was decided to fix a date for the first trials prior to the official opening of the whole line some little time later. It was arranged that on the 30th of August an engine should be tried over the line as a preliminary to other trials.

On the approach of this day every possible effort had been made to ensure completion by the date required, and, when the time arrived, only one short piece of embankment remained to be finished.

In the early morning of August 30, 1858, a large gang of navvies quickly built up the earthwork to the height required—some 25 feet—and as soon the platelayers laid the last length of rail. A message was at once sent to the engine sheds at Los Corralles that the line was through, and before long engineers and contractors had left on the first trip to Santander, and ultimately travelled the whole 26 miles without incident, the permanent way being carefully examined and found in excellent order. Upon arrival at Santander, naturally every one was greatly elated over the successful result of their long and weary labours, and, as soon as it became known that

the trip had been successfully completed, there was an unanimous appeal from the Spanish directors and officials for another trip over the line that same day, and their wishes were acceded to by Alfred Jee with alacrity, for his task as engineer-in-chief had been one of great trial and constant worry and the success attending this event naturally gave him the most complete satisfaction.

With every confidence some carriages and wagons were coupled on behind the train, and a party of some forty or fifty entered the vehicles.

On the engine went Alfred Jee, his brother and assistant, Morland Jee, and James Livesay, driving the engine (one of the 'Ysabel' type); in the carriages were various directors and their friends, and in the wagon immediately behind the tender were the two Messrs. Mould, the contractors; M. Porrua, Chairman of Directors; the well-known Spanish engineer, Don Carlos Campuzano; and others, thirteen in all. All went well until the train arrived at the newly completed piece of line. Here, as if in bitter irony as to what was going to happen, an evergreen arch, bearing the word 'Success,' had been carefully made and erected over the line, and, just as the train reached this point, the engine and tender went off the rails and rolled down the embankment, then

turned completely over. It finally remained on its side at the bottom, having dropped 25 feet The tender remained upset on the slope in a most dangerous position. Those in the wagon were all thrown out and escaped with nothing worse than bruises.

Of these John Mould was the first to regain his presence of mind, and proceeding to the engine he was shocked to find Alfred Jee and his brother pinned under one of the driving wheels with the scalding water from the boiler streaming over them, their heads projecting clear of the wheel rim. The fire had been thrown out of the furnace over the unfortunate sufferers and would have burnt them but for John Mould's prompt action in throwing earth on the fire and thus damping it out. Morland Jee was subsequently removed from under the engine, although two hours elapsed before the necessary aid was forthcoming for this to be done, and he was then taken to the town of Los Corralles, where he died shortly after.

The banquet which had been provided by G. Mould, the contractor, at his residence in this town in honour of the occasion, had to be cleared to make way for the injured and dying. Truly a tragic ending to a day of great rejoicing.

At the time of the accident the speed of the train was not more than six or seven miles an

hour, and the newly-finished embankment had twice been traversed that day and had appeared perfectly safe. It was thought that a loose rail may have been the cause of the disaster, but the true reason was never discovered. With the exception of the engine, tender and first wagon, the train remained on the track.

The saddest feature of the accident was the death of Alfred Stanistreet Jee, who was killed instantly. He was one of the leading and most successful civil engineers of that day; born in 1816 at Liverpool, he was at sixteen years of age accepted as a pupil by Joseph Locke, then a rising member of the profession; on the completion of his training he was made resident engineer of the Lancaster, Preston and Junction Railway. In 1840 he took a very prominent part in the construction of the Sheffield and Manchester Railway, also the Huddersfield and Manchester line, and between that year and 1845 constructed the Dinting and Etherow Viaducts; and perhaps his greatest work of all was the Woodhead Tunnel, which he engineered from beginning to end.

Like many others he realized towards the approach of 1850 that railway engineers at home must for their future existence look abroad, where the railway movement was just beginning to gather strength. This brought him into contact

with others in the same branch of the profession, and in this way he met his friends Isaac Dodds and George Mould, whose intentions were identical with his own, the outcome of this event resulting in their Spanish venture. Jee had an extraordinary aptitude for learning foreign languages, and within a short time of his arrival in Spain was able to converse freely, and use the technical terms of that country, in his dealings with Spanish engineers. After conquering almost overwhelming difficulties there, and expending years of toil and patience in overcoming obstacles of no ordinary character, his life was cut short at the early age of forty-two. His death was the source of great sorrow both to his Spanish colleagues, with whom he was very popular and highly respected, and his own countrymen. His death was a great blow to Messrs. Dodds, for their friendship had been of a most intimate and personal character.

The bodies of the two brothers were brought to Santander to be taken by sea to England. When transferring their remains to the vessel, the populace of that seaport turned out *en masse* to pay a last tribute to their dead benefactors, who, they all knew, had done so much to render their country every service possible.

CHAPTER X

LAST INVENTIONS

In 1863 various steel manufacturers approached Messrs. Dodds with a view to obtaining facilities for the extended application of their process of manufacturing steel. Among these gentlemen were the well-known names of Beale of Parkgate, Robinson of the Ebbw Vale Iron Co., and Thomas Bell of Gateshead. As the prospects of this system of steel-making appeared in their judgment to be exceptionally bright, they proposed wide developments to the inventors, and eventually an agreement was arrived at giving satisfaction to all parties interested.

In the middle of the year a company was formed under the title of Dodds' Iron and Steel Patent Licensing Company, with offices in Sise Lane, London, and for some years proved very successful.

Some of the most important parts of T. W. Dodds' discoveries had, however, not been fully covered in his Specification of 1853, for certain

details which were transmitted to the Institution of Mechanical Engineers in 1857 at Manchester had not been covered in the Patent Specification of 1853, and this loophole was the means of losing valuable revenue which should otherwise have fallen to their reward. In December, 1865, a number of these belated inventions were, at the instance of the Licensing Company, in some measure protected by a patent granted for 'Improvements in the Manufacture of Railway Bars, Tyres, and Axles.'

Special Tyre 'steeling' furnaces were included in this; their mode of working will be seen by reference to Fig. 23. Provision was made for obtaining uniformity of heat in the cementing chambers of the various types of furnaces peculiar to Messrs. Dodds' arrangements; chimneys and dampers being applied to each side of a furnace, in case of side flues, the communicating passages with these chimneys could thus be separately opened or closed as required, thereby giving facilities for the perfect regulation of the heat; a quality impracticable when using a single chimney. The last claim granted was that for condensing or consolidating the rails after their withdrawal from the converting furnaces by passing them through a rolling mill, for which a special design was stipulated.

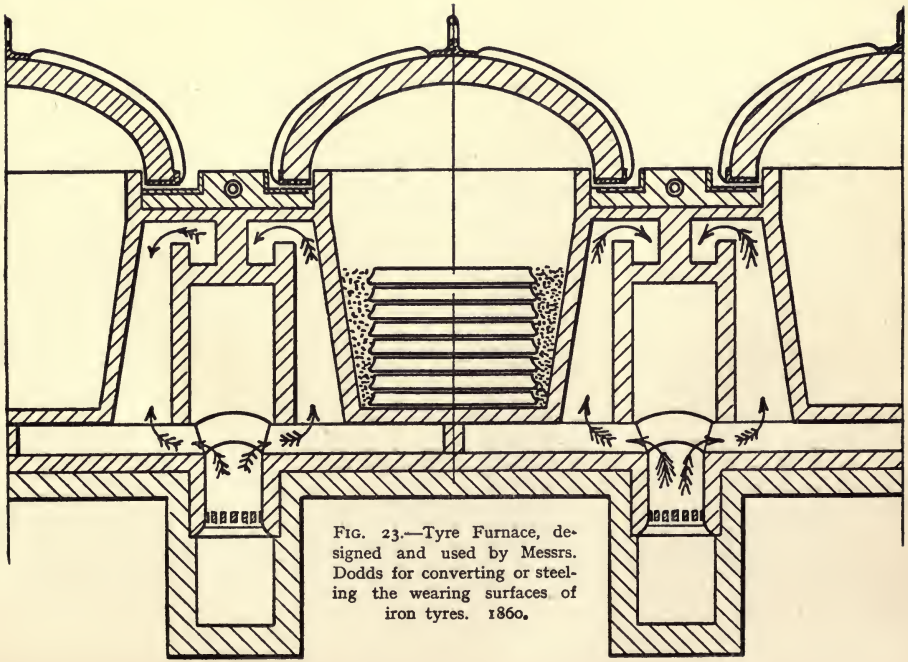


FIG. 23.—Tyre Furnace, designed and used by Messrs. Dodds for converting or steeling the wearing surfaces of iron tyres. 1860.

SADDLE-TANK LOCOMOTIVE

Designed and built by Messrs. Dodds for Messrs. Benton and Woodiwiss (Contractors for sections of the Manchester, Sheffield, and Lincolnshire Railway), 1865.

About this period Messrs. Dodds were largely engaged in erecting iron and steel-making plant for manufacturers in the U.S.A., where their name and inventions held a reputation far greater than in these Islands. Earlier in the 'sixties' they put down for Andrew Carnegie his first rail rolling mill, together with their improved furnaces for steel conversion, workmen being sent over from the Holmes Engine Works to superintend the erection at Pittsburg. As a result of their successful work here a large amount of trade was carried on and their process was widely adopted; other systems adopted by the Americans for steel conversion having failed, although originated in England and worked there with some measure of success.

The introduction of the Bessemer process, however, prevented more extensive development and the use of their furnaces was afterwards restricted to the manufacture of high-grade carbon steels for tool-making. The high quality and soundness of their productions made a very deep impression on the American engineers, who gave many tokens of their high regard for the abilities and inventive genius of Messrs. Dodds. Between 1860 and 1870 no name stood higher in the estimation of the Americans than Isaac Dodds and his son as engineers and inventors.

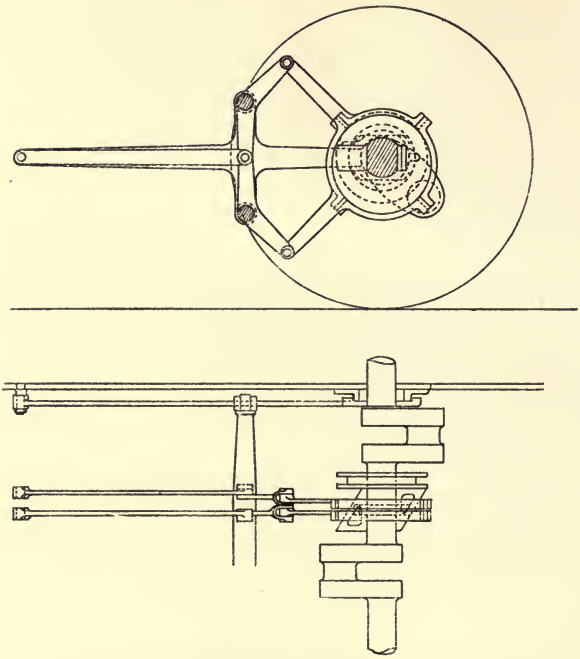


FIG. 24.—The final development of the Wedge Eccentric Motion. Views showing the two straps mounted on one sheaf, the rocking shaft is carried on side levers attached to the axle in order to compensate vertical movements of the axle, which would otherwise produce undesirable variations in the travel of the valve.

The Final Efforts at Mechanical Inventions

One of the last devices made by Messrs. Dodds was a development of the Wedge Expansive Motion, two eccentric straps and one sheaf being used instead of the two separate sheaves hitherto employed. One valve was driven direct, and the other by means of a rocking shaft suspended on side levers (Fig. 24); this design being standardized on the North Staffordshire Railway some years later, when T. W. Dodds became Locomotive Engineer of that line.

At the same time Messrs. Dodds proposed a new method of relieving the slide valves of inside cylinder engines from excessive back pressure, for in the case of an ordinary slide-valve the weight on the back due to the steam pressure would be as much as 10–15 tons. The two valves were to be separated by means of a division plate (Fig. 25) packing rings being fitted into the plate and pressed outward by springs on to the backs of the valves.

Fig. 26 shows a type of axle-box used on locomotives designed by Messrs. Dodds; in this a certain amount of play was given to the axle-box to allow the bearing to maintain even contact with the axle journal in the event of vertical movements while the engine was running, the

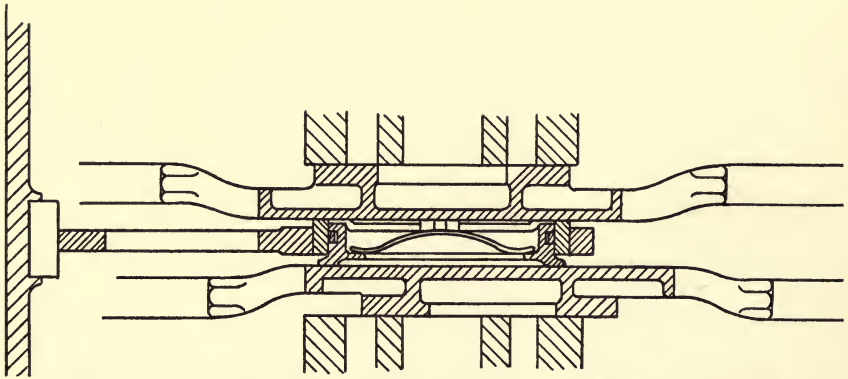


FIG. 25.—Arrangement employed by Messrs. Dodds for relieving the valves of inside cylinder locomotives from steam pressure.

top of the brass being convex in shape and working in a corresponding bed cast with the main part of the axlebox.

Some of these improvements were patented in

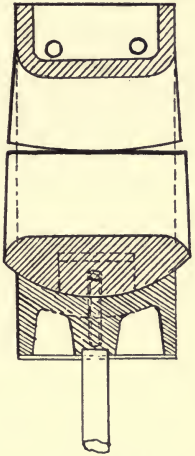


FIG. 26.—Axle-box designed by T. W. Dodds for avoiding flange breakage generally due to the oscillation of the axle.

1871, and proved to be the last so protected by these prolific inventors.

Since 1833 Isaac Dodds and his son had patented over sixty inventions and had spent,

apart from the cost of the experiments, a sum no less than £10,000 in obtaining the protection of Letters Patent. In addition to these, a very large number of designs were registered at the Patents Office as 'Articles of Utility.' Scores of other devices brought out by them were never protected, but were given freely for general application. Like most men who possess the inventive faculty to a high degree, Messrs. Dodds frequently became the losers at the hands of that parasite the 'brain-picker,' and on many occasions saw others meanly take advantage of their generosity to enrich themselves.

CHAPTER XI

SERIOUS DIFFICULTIES IN SPAIN

SINCE 1850 Dodds and Son had carried on a very extensive trade with the Spanish Government, and until the year 1866 had no reason to be dissatisfied with the results. They had constructed the greater part of the Santander and Alar Railway and many branch lines, and, notwithstanding the unsettled condition of that country, had succeeded in obtaining reasonable payment of their claims. The long corrupt reign of Isabella II, however, showed signs of breaking up, as the numerous rival political factions of that country, who, up to that time, had been more or less content with the milder forms of opposition, began to show signs of more vigorous action. The Queen's power had for many years been upheld by the strong but merciful hand of General Narvaez, who succeeded in maintaining some measure of discipline and loyalty in the Army. So long as this prevailed the Throne was kept intact and the various rebellions were quickly suppressed.

From 1866 to 1868 the situation altered, Narvaez went out of office and his successor, in attempting to exterminate every rebel in the land, himself was the victim of his own policy. The finances of the State collapsed, foreign credits were practically unobtainable, and the great work of modernizing the country by building new railways, roads and harbours was only part completed; great dissatisfaction ruled in both commissioned and non-commissioned ranks of the National Army, and futile wars with Chili and Peru merely meant the 'pouring of oil on the smouldering fire.'

The Carlists, taking advantage of the precipitous position of the rulers, gathered their adherents and for some time seriously threatened the overthrow of the Monarchy. This brought Narvaez back to power, who checked the rising, and succeeded in again proclaiming law and order. Practically all work was, however, at an end, long outstanding payments were due to numerous contractors, who, in consequence, had suspended their operations.

Many of the sub-contractors on these works, who were superior British tradesmen, returned to their native land penniless and in want. Messrs. Dodds hoped that the conditions would improve as the result of the reappearance of Narvaez, but

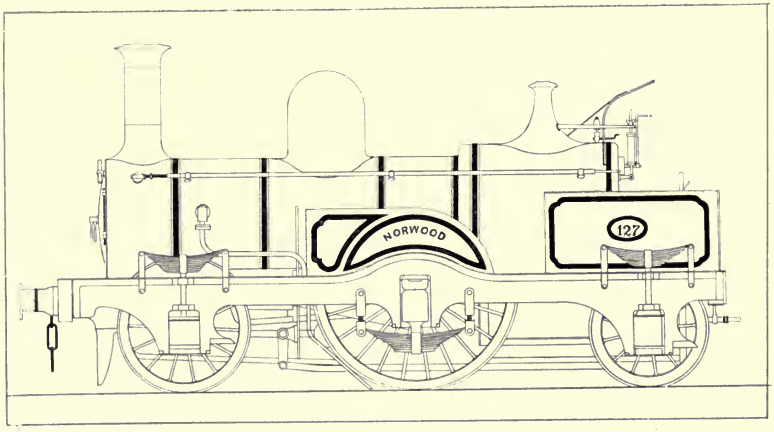


FIG. 27.—TYPE OF EXPRESS LOCOMOTIVE BUILT IN 1866

their worst fears were realized when they received the news of his death. Following upon this towards the end of 1868 large parts of the Spanish Army openly mutinied and joined the Revolutionaries; subsequently they raised their banner and advanced on the capital, where they defeated the Royalists. Queen Isabella fled across the frontier into France, never to return. Complete chaos reigned throughout Spain following these events, and all national financial obligations were indefinitely nullified.

The End of a Great Career

This disaster subsequently proved irretrievable, as a very large sum of money was involved, and it did not appear likely that the situation in Spain would alter for a considerable period; under these conditions, in addition to the financial panic then extant throughout Europe, the creditors were unable to grant Messrs. Dodds an adequate period in which to balance and re-adjust their huge Spanish financial affairs. The firm was, therefore, compelled to go into liquidation and realize the whole of its available assets.

In 1868 the Holmes Engine and Railway Works closed, never to be used again as an engine factory. An order from the London, Brighton and South Coast Railway (received in 1866) for six express

locomotives was never completed, only one engine being finished while the second remained in the maker's shops for many months afterwards. The first of these splendid machines (Fig. 27) was subsequently sent to the Brighton Works of that railway in 1871, there to undergo her trials and ultimately take her place on the 'iron road.' Some time afterwards the second, and partly completed engine, was delivered at the same place; there to be made ready for work by the addition of the motion which had not been fixed before the close of the establishment.

These engines did splendid service for many years after, the first engine (No. 69 in the maker's books) was christened 'Norwood' by the late Mr. William Stroudley, and the second (No. 70) 'Croydon.' They were numbered by the Railway Company 374 and 375; the latter did excellent service for nearly twenty years before ending her days, and 'Norwood' followed her in December, 1892. They were both subsequently broken up and consigned to the scrapheap at Horley.

Isaac Dodds never entered into business again, but retired, and went to live with his son, Thomas Weatherburn Dodds, in Sheffield. There for ten years he lived until his death on November the 1st, 1882. During the latter part of his life he was frequently called upon by many authorities

to advise them in various engineering matters. Among the older members of the engineering profession he was held in great esteem, only those who were acquainted with him intimately knew of his great services to engineering science. He could never be persuaded into any kind of publicity; history, in recording the great works of our Victorian engineers, fails to find a place for him, yet who can deny his right to a high place therein after knowing some of his works as given in this imperfect story?

He was a great mechanic; throughout his life he possessed wonderful skill with his hands and even at the close of his days, at eighty years of age, he could execute unique examples of his craft. He would even then frequently prove to his friends that great age had not diminished these powers by taking a sixpenny piece, and, after smoothing one face, engrave on it in the most beautiful handwriting every word of the Lord's Prayer.

Like Nasmyth, Bessemer, and other great inventors, he was a brilliant artist. His drawings of machinery are perfect specimens of the draughtsman's art, the shading and colouring are exceedingly fine. Some of his etchings are of singular beauty, and are undeniably the work of a master hand.

Writing of Mr. Dodds in an Obituary Notice, the late Mr. Charles Manby says:

'Mr. Dodds possessed great general kindness of character. He always assisted aspirants for invention, and corrected their errors so as to prevent their waste of time and money, advising them how to proceed. He was a man of simple tastes, but of large desires to know everything, generous to a fault, and not careful of his own interests. He was scarcely appreciated during his lifetime, and it is only just now to judge him by what he did during his lifetime.'

He was treated with great respect wherever his labours took him; an old resident, writing in one of these districts after Mr. Dodds' lamented decease, recalled to mind some of the interesting stories connected with both father and son. He writes: 'I can imagine I still meet his once much respected and venerable personage as I was accustomed to do in the days of my youth, as he traversed the thoroughfare of the Holmes while on his way from "Ordnance Villa" to the Engine Factory at the Holmes. His pleasant countenance and outward appearance altogether bespoke that of a real old English gentleman.'

The burial of this old 'Pioneer' of our railways took place at the General Cemetery, Sheffield.

Thomas W. Dodds had, on the closing of their

Holmes Works, accepted the position of Engineer and Locomotive Superintendent to the North Staffordshire Railway Company, and also of Engineer to the Trent and Mersey Navigation Board, where he did much valuable work in connection with the reorganization of his departments.

In 1882 he was commissioned to visit the Transvaal, to make a report on railway extensions and on gold mines at Lydenberg, Pretoria, Johannesburg, and Spitzkop. He remained there for six months. In 1884 he was appointed General Manager of the Sante Fé Colonial Railways, where he was occupied for three years.

He returned to England in 1887, and in 1892 was sent to South America to investigate the causes of the high cost of working on the Buenos Ayres and Pacific Railway. He was given executive powers to act as he considered necessary, and the results fully justified the confidence his directors had placed in him.

During his administration of this railway the service was much improved. The stations along the line, the main track, the workshops, the rolling stock, the service of trains, all reflected his admirable management, his untiring care and his great zeal to keep his railway at the highest possible standard. His career as a Railway Manager in the River Plate was on a parity with

his high antecedents as a civil, mechanical and mining engineer. In Buenos Ayres he was a universal favourite, and on his departure in 1896 the staff of the railway which he managed gave him a grand banquet, and took the opportunity of showing their admiration and affection for his genius as an Engineer and his delightful personality.

He was subsequently appointed General Manager of the line with a seat on the Board of Directors, in residence at Buenos Ayres. Unfortunately his health, as a result of the climate there, became seriously affected, and in 1896 he was compelled to retire. He never thoroughly recovered, for on the 6th September, 1899, he died at his residence, Carter Knowle Road, Sheffield, and was interred at Sheldon Cemetery, Hanley, in Staffordshire.

He was a man of exceptional ability as an engineer, being equally conversant with almost all branches of engineering. We have recorded his ingenious designs and inventions in Ordnance, Shipbuilding, Metallurgy, Railway Apparatus, and also his works in connection with Civil Engineering; his knowledge was, therefore, of a most versatile nature, his early training as a civil engineer under Sir James Falshaw in the construction of railways, and the training as a

mechanical engineer received from his father gave him every opportunity of obtaining a true understanding and clear insight into all problems of the mechanical and civil engineers' creations.

Like his father, he possessed extraordinary practical capacity and could make with his own hands the most perfect models of their manufactures. The workmen of the Holmes Works regarded this gift as being supernatural, for on one particular occasion it is related that he made a watch no bigger in diameter than a shilling piece which was as good a timekeeper as any watch could be. Every detail of this intricate piece of mechanism was made by him, with the crudest instruments.

Both engineers belonged to the class of Corporate Members of the Institute of Civil Engineers and were at one time Members of the Institute of Mechanical Engineers.

Old workmen of the Messrs. Dodds who served their apprenticeship with them tell with great pride of the remarkable experiments and inventions which were always being tested at the Holmes Works. The whole of their plant consisted of machinery self-designed and constructed, and their products were invariably of superb finish. Both masters personally examined everything before it left the works; if there was the

slightest trace of faulty workmanship the article in question would be returned to the shops and the worker responsible admonished for his shortcoming. Although Messrs. Dodds obtained a great reputation for their splendid work, they never made large commercial gains and at frequent times in their history financial embarrassment cut short their enterprises, for they did not, perhaps, fully appreciate the importance of commercial questions, and, with the modesty characteristic of true genius, never encouraged or sought any kind of appreciation outside the bounds of their own small circle of friends.

In conclusion, it is not without considerable regret that one looks back upon the life works of many great inventors and, in following their careers, observes how they almost invariably suffer from the desires of others to profit at their expense, also that the gifts of genius are often the cause of great self-sacrifice on the part of their possessor, so frequently do we find that those of our countrymen whose exceptional abilities have given us the means of improving the conditions of life, have failed to reap their proper reward, and at the end of their day have found little material benefit or public acknowledgment fall to their lot. In his ' Stanzas on the Opening

of the Sheffield and Rotherham Railway,' the poet Elliot, it will be remembered, wrote :—

> O Genius : all too long, too oft,
> At thee the souls of clay have scoffed,
> And sold thy little ones !

To this Elliot adds in explanation, ' I do not believe that men of genius are less able than other men to gain their living ; but, if they attempt more, they are more liable to failure, but if they live where men are robbed of three-fourth of their earnings, is it surprising that they do not thrive ? '

Messrs. Dodds did not reap their due reward for their great efforts and sacrifices which they made throughout their lives for the benefit of engineering science ; and although this record, written many years after their decease, is naturally very far from being complete, surely sufficient evidence has been stated to place them on a parallel with the most eminent of our nineteenth-century engineers.

. . . . .

The writer has to acknowledge the valuable assistance freely given by many whose acquaintance with the subjects of this record reach back over half a century. Much information and help

have also been forthcoming from Miss C. E. Dodds (whose father was Mr. T. W. Dodds), and who has kindly lent photographs for reproduction.

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